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EXECUTIVE COMMITTEE OF THE DOMINION MINING CONFERENCE,
DUNEDIN, 1926.

Back row: Messrs A. C. M'George, G. Duggan, W. F. Sligo, W. A. Flavell, J. M'G.
Wilkie, A. Whitley, H. Crawford.

Proceedings, Papers, Remits, and Discussions

OF THE

DOMINION MINING CONFERENCE

HELD AT

DUNEDIN - NEW ZEALAND

FEBRUARY 3rd to 6th, 1926.

Honorary Editors:

Prof. J. PARK and Prof. D. B. WATERS.



DUNEDIN:

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Place of Meeting: Allen Hall, Otago University, Dunedin.

LIST OF MEMBERS.

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 CRAWFORD, W., Managing Director, Mossbank Coal Company.
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VII.

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 SLIGO, W. F., Sharebroker, Dunedin.
 *SLIGO, N. K., Quarry Manager, Dunedin.
 *SMYTHE, Jas. R., Company Director, Lawrence.
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Those marked thus * were absent members of Conference.

FOREWORD.

"After 35 years, mining men confer." It was with these words that the Evening Star of Dunedin opened its description of the Dominion Mining Conference held in Dunedin from the 3rd to the 6th of February, 1926.

On June 2, 1925, a meeting of gentlemen connected with mining was convened and attended by twenty-five persons representing such bodies as the Institute of Mining and Metallurgy (London), the Australasian Institute of Mining and Metallurgy (Melbourne), the New Zealand Coal Mine Owners' Association, the Otago and Southland Union of Gold Mine Employees, the Institute of Civil Engineers, the Dunedin Stock Exchange, and the University of Otago.

After discussion it was decided to hold a Conference of those engaged in and connected with the mining industry in New Zealand. By common consent Professor Park was elected President.

The Executive Committee desires to express its appreciation of the way in which the Hon. G. J. Anderson, Minister for Mines, has assisted the movement from its inception, by promising a grant to defray printing costs, also by placing the whole strength of the Mines Department staff behind it; and lastly by acting as Patron and opening the Conference. The sympathetic attitude of the Minister has been of great value.

The Committee throughout its period of work has received assistance from many people, and begs to thank all who contributed to the fund for general and entertainment expenses.

The donors to this fund were the Westport Coal Co., Ltd., the New Zealand Coal and Oil Co., Ltd., the Jubilee Coal Co., Messrs Sargood and Cheeseman (Taratu Coal). The Kawarau Gold Mining Co., Messrs J. Loudon and Co., Edgar Hazlett, Esq., Jas Horn, Esq., M.P., The Linton Coal Coy., Messrs John McGregor and Co., The Dunedin Stock Exchange, The Otago and Southland Industrial Union of Gold Mine Employees, the Rimu Gold Dredging Coy., Puke-miro Collieries, the Taupiri Coal Coy., The N.Z. Gold Mine

Owners' Association, Messrs Jos. and A. C. McGeorge, the St. Bathans Gold Mining Coy., the Waipa Rail and Coal Coy., Messrs W. and F. Carson, the N.Z. Coal Mine Owners' Association, Glen Afton Collieries, Messrs A. Morris, Thos. A. Turnbull, J. McLelland, L. O. Beal, and F. S. Mance.

The last Dominion Mining Conference was held in Dunedin in 1890, and the ready response to the invitations to the Conference of 1926 shows that the conception of the Executive Committee formed in June, 1925, has been fully realised.

The President and Executive Committee have much pleasure in presenting this volume as a record of the Conference of 1926.

PROCEEDINGS.

WEDNESDAY, FEBRUARY 3, 1926.

At 9.30 a.m. members of the various bodies already mentioned and others associated with the Mining Industry assembled at the Allen Hall, Otago University, Dunedin, and one hundred and seventeen signed the roll sheet. The total number was brought up by others coming later to one hundred and twenty-three.

At 10 a.m. Professor Park, President, took the chair, and associated with him were the Hon. G. J. Anderson (Minister of Mines), Mr H. L. Tapley, M.P. (Mayor of Dunedin), Mr T. K. Sidey, M.P. (Chancellor of the University), Mr J. Horn, M.P., Mr T. W. Rhodes, M.P., Mr A. H. Kimbell (Under-secretary for Mines), and Mr F. S. Mance (Under-secretary for Mines, New South Wales).

PROFESSOR PARK (President), in his opening remarks, said: This is New Zealand's second Mining Conference. The first was held at Dunedin thirty-five years ago in connection with the New Zealand and South Seas Exhibition of 1889-90. It was organised by the Directors and Commissioners of that Exhibition, and formed part and parcel of the official programme. Needless to say, it was a great success, and gave a powerful stimulus to mining throughout the whole Dominion.

The present Mining Conference, which I am glad to see so largely attended, has no connection with the New Zealand and South Seas Exhibition of to-day. It was organised by a number of Dunedin's leading citizens, all of them gentlemen connected with the mining industry. They formed themselves into a strong Executive Committee for the purpose of making the necessary arrangements. From the first it was recognised that the success of the gathering would depend mainly on the reading and discussing of original papers. This at once raised the question of ways and means, and it was agreed to approach the Minister of Mines for help. Armed with estimates for printing and binding, a deputation of the Finance Committee met the Minister and asked for the sum of £250. It did not take him long to perceive that such a gathering of mining men could not fail to stimulate mining, and I am gratified to say he had no difficulty in agreeing to our request. More than that, he promised that the Conference would be backed by the full strength of the Mines

Department. On behalf of the Executive I wish to express our sincere thanks to the Minister for his practical help and moral support, both of which count for much.

Our thanks are also due to Mr Kimbell (Under-Secretary for Mines), who from the first entered into the spirit of the enterprise with characteristic zeal. Not only has he contributed two useful papers, but in season and out of season, in all parts of New Zealand, he has urged mining men to attend. He has also made it possible for many of the officers of his department to be with us to-day.

Our acknowledgments would not be complete without a reference to Professor Waters. The germ of the conception to hold a Conference originated with him, and to punish him for his sins we made him honorary secretary. Recognising the justice of the penalty, he put his back into the job, and, notwithstanding that he was handicapped by a serious illness, he has carried out his duties with a punctilious fidelity that finds visible expression in this distinguished gathering. To him and to his assistant, Mr Crawford, we wish to express our great indebtedness.

Further acknowledgements are due to all the persons and Mining Companies who have given donations to cover the heavy charges incidental to the organising and running of the Conference.

Thirty-five years is a long span in human life, and all but a handful of the members of the first Conference have passed beyond the Great Divide. It is therefore all the more gratifying to see Mr Beal with us this forenoon forming a living link between the past and present.—(Applause.)

I have now much pleasure in asking the Hon. G. J. Anderson to address the meeting, and to declare the Conference open for the transaction of business.—(Applause.)

HON. G. J. ANDERSON, Minister of Mines, who was received with applause, complimented the Executive Committee upon its good work and Professor Waters upon his very brilliant idea—for so it was to his mind—of holding a Mining Conference at this particular time. The undertaking had entailed a vast amount of very heavy work, and all those connected with the Conference deserved the greatest credit. (Applause). He was sure that the results of their meetings would be worthy of that great work, and that much good would be done to mining.

It is (added the Minister) with the deepest feelings of appreciation that I rise to make a few remarks as patron of this Mining Conference. As the son of one of the early mining pioneers in the Otago Goldfields, and as one who was reared on those goldfields, may I assure you that I regard it as a very high honour indeed to be asked to act as Patron. The occasion of the opening of this conference is of historical importance in so far as the city of Dunedin is concerned. As many of you are probably aware, the last Mining Conference which was held in this city took place in March, 1890, at which time the New Zealand and South Seas Exhibition was being held. On this occasion a similar, but much more ambitious, Exhibition is being held.

MINING AND EMPIRE PROSPERITY.

He continued, I am particularly pleased to see such a large attendance here to-day. It, to my mind, indicates clearly that there is still a lively interest being maintained in mining. The progress of this Dominion has been greatly indebted to mining. From time to time in years gone by and during times of depression the mining industry helped materially to keep the country buoyant. I am sufficiently optimistic to believe that the future will again show that mining may be relied upon as one of the industries which will keep this grand little country of ours prosperous. May I express the fervent hope that the results of this conference will be of a highly beneficial character. The interchange of ideas and the establishment of personal contact and friendship between men from all parts of the Dominion and from Australia, all of whom are animated by similar ideals and many of whom are actively engaged in mining, must have a beneficial influence upon this great industry.

You will all realise that mining has played a most important part in the development of the British Empire, and so long as mining continues prosperous throughout the Empire I for one am firmly of the opinion that its prosperity will endure and its progress be maintained.

I suggest that in your deliberations and discussions you should at all times refrain from introducing politics in your remarks. As you know, this is neither the time nor place for politics, and I feel sure that better results will follow if we carefully eliminate from our discussions matters that may have a political tendency. Mining is above political parties or issues. This conference will, I hope, place suggestions before me which will be of universal benefit to the community.

OF MINING REVIVAL.

do from time to time through those portions of the Dominion where the mining industry still prevails, I have noticed recently that there are indications of a mining revival. I have also noticed that in some cases great pains are being taken by men who understand their business to prove the mineral values of the areas held by them by systematic prospecting before embarking upon an enormous expenditure in development in the purchase of equipment and plant. I have come to the conclusion that many of the failures in mining in the past have been due mainly to the fact that the persons who promoted companies had not prospected sufficiently and proved the mineral value of the land held by them. All those who have the mining industry and the welfare of this Dominion at heart know only too well that it is absolutely essential to prospect on systematic lines so as to prove the mineral values of mining claims before inviting the public to subscribe large sums of money to work such claims.

NEED FOR BUSINESS METHODS.

Mining operations should be carried out on business lines like any other business; but, unlike many other businesses, mining is more or less speculative, and it is in all cases difficult to estimate what the results of any venture will be. If a mining project proves successful, prudence demands that a reserve fund should be established as quickly as possible, so that when the mining operations for the time being do not pay expenses that fund may be resorted to for the purpose of keeping the mine going. Had such a course been adopted and carried out in the past, I feel sure that many of the mining companies which became defunct for want of capital to carry on might have continued working, and might even be in operation to-day.

In several instances I have noticed that companies have been floated in New Zealand and in Australia to work mining claims in New Zealand without any prospecting whatever having been previously carried out. In some of these cases the promoters have obtained for themselves large cash considerations for properties which had not been prospected; in others promoters' shares have been allotted far in excess of what was reasonable. There can be only one result if such a method continues. If this is not discontinued those persons who have spent large sums of money in prospecting, and who have proved their claims, will find it very difficult indeed to raise capital to work their claims.

GUARDJANS OF PUBLIC.

The stock exchanges transacting business in the Dominion are interested in this question. They should be the guardians of the public in such speculative stocks, and they should, therefore, exercise very great caution before listing the shares of any mining company of the character I have indicated. They should be quite satisfied that the vendors who have promoted companies have not been too grasping. Further, they should seriously consider the question of making it a stringent condition not to list promoters fully paid-up shares until such time as the mine commences winning gold, or dividends are in sight. If this were done, I feel confident that the public, who are invited to find money from time to time for mining, would have greater confidence and would more readily purchase shares than has been the case in the past.

I sincerely hope that, in discussing the remits, the delegates to this conference will direct their remarks to the bona fide development of the mining industry, and to the best interests of the public, who may from time to time be called upon to subscribe money for such a purpose.

CHEAP POWER ESSENTIAL.

Another observation that I desire to make arises from my visits to mining districts. There is great need for cheap hydro-electrical power being made available by power boards for mining. I feel confident that with cheap power a number of mining ventures that had to close down operations could be revived again. Some of these ventures had to pay enormous prices for their fuel for power purposes, with the result that they could not successfully carry on mining.

As most of you are aware, it is becoming increasingly difficult to carry on profitable mining operations owing to the fact that most, if not all, the easily-won gold has been worked. There still remains, however, lodes or reefs containing poorer values to be prospected, developed, and worked. To ensure financial success a large amount of money would require to be made available for working such reefs on a large scale and with cheap power. It is absolutely imperative, moreover, that before embarking upon such expenditure the very best advice from highly skilled mining engineers should be obtained as to whether or not the prospects are such that a mine could be opened and worked profitably. It is really astonishing to me at times to find how little is known by the claim-holders of many of the quartz mines which have been closed down.

LOANS AND SUBSIDIES.

Applications for loans and subsidies have been made to me from time to time during the past few years. Arising out of the investigations made by the department's board of officers, it has been shown that very incomplete information of the results obtained by prospecting and mining of such properties, before they were closed down, was available. The plans had not been kept up to date. This was a most important omission. Systematic sampling and assaying had not been carried out. In some cases it was obvious that those who were applying for subsidies and loans had not really grasped the most elementary essentials connected with their ventures. In fact, some of them had been misleading themselves as to the prospects of their ventures until the members of the board had informed them of the real position.

Several years ago it was realised by me that the method of granting one or two prospectors a subsidy for prospecting areas of country was not satisfactory. I endeavoured to make arrangements with a local authority to employ a reliable party of prospectors headed by a mining engineer with geological experience. The department offered to pay two-thirds of the cost of the proposed undertaking, but, unfortunately, the local authority was not able to find the other one-third of the expense involved, and consequently the proposal was dropped. I am still prepared favourably to entertain any application that may be made by or through a local body or a Miners' Association to be granted a subsidy for a reliable party of prospectors, headed by a mining engineer. When, therefore, you are deliberating upon the remit dealing with the matter of aiding metalliferous mining, may I ask you to bear these remarks in mind.

MINES CONSOLIDATION BILL.

I observe that there is a remit urging that the Mining Act, 1908, and its amendments should be consolidated. You will all be pleased to hear, gentlemen, that from time to time during the past three or four years I have endeavoured to arrange for this to be done, but, unfortunately, owing to the pressure of other work, the matter had to be deferred. The Compiler of Statutes is, however, now engaged in preparing the necessary Consolidating Bill, and I hope to have the pleasure of introducing the same during the next session of Parliament.

UTILISATION OF COAL SLACK.

Another matter to which I desire to allude is the better utilisation of coal slack. For some time it has been apparent to me that large quantities of coal slack have been wasted, owing to want of a market. This has resulted in serious loss. If such slack could be used commercially it would be a national asset. Realising, therefore, the importance of the matter, I arranged about a year ago to engage the services of a highly-qualified scientist for the purpose of making experiments in the manufacture of briquettes from samples of bituminous coal, brown coal, and lignite, from representative mines throughout the Dominion. As the result of nearly a year's work, it has been shown conclusively that briquettes can be made from the several classes of coal by means of a binder; but it has yet to be demonstrated that briquettes can be turned out on a commercial basis. I understand that, up to the present time, neither in Great Britain nor in the United States of America is there a plant to treat coal by a process of low temperature carbonisation with satisfactory commercial results. I also understand that the estimated cost of the erection of a suitable plant for dealing with a substantial daily output would involve the expenditure of over £100,000. I trust, however, that as the result of your discussion of the remit dealing with the utilisation of coal slack it may be possible to devise some practical scheme to render this waste product a commercial commodity. If this could be brought about, the coal industry would be greatly benefited.

TO "UP-GRADE" COALS.

Some time ago arrangements were made by me to engage the services of Mr Wm. A. Bone, D.Sc., Ph.D., F.R.S., professor of chemical technology, of the Imperial College of Science and Technology, London, to investigate five samples of New Zealand coals, representative, respectively, of the coals mined at the Kaitangata colliery, Reefton No. 4 seam, Taupiri Rotowaro colliery, Waipa colliery, and some lignite from the Mataura collieries. Professor Bone's report has recently come to hand, and in it he has expressed the opinion that the best prospect of utilising these coals commercially would be—(1) as pulverised fuels for the firing of boilers or reverberatory furnaces; or (2) as briquettes, after being crushed and briquetted with the addition of some 4 or 5 per cent. of pitch or other suitable binder. He considers, speaking generally, that probably a suitable process of low temperature carbonisation (say at 550 to 600deg. C.), when

such becomes commercially available, would be the best means of "up-grading" these coals; because, in addition to yielding satisfactory amounts of fuel oils, the residues, which would be free-burning and smokeless in their combustion, could readily be used either as pulverised fuels for steam generation and the like or as briquetted fuels.

SAFETY FIRST.

I think that on this important occasion I may be permitted to remark that throughout my term of office as Minister of Mines I have laid it down from time to time as a cardinal principle to my staff that safety must come first in coal-mining operations; and, so long as I remain in office, my firm intention is to see that that principle is adhered to.

"It is to be very much regretted that in earlier years many coal mines were opened and worked without due regard to the future and to that efficiency which the industry in the interests of the country requires.

The number of fires that have occurred in coal mines in several parts of the Dominion during the past twenty years is really appalling. Many of these could have been obviated had scientific methods of working been adopted when the mines were first opened out. As a consequence, large quantities of valuable coal have been irretrievably lost to the Dominion. I am pleased to say, however, that during the past two or three years an improvement in the method of working has become apparent. Coal mines should be so managed and worked that the risk of accidents to workmen and of fires would be reduced to a minimum.

REDUCED MINING COSTS WANTED.

As you are aware, the coal industry is not at present in that flourishing condition financially which we would all desire. This may be attributed to several causes, some of which may be mentioned at this stage: Firstly, the conversion of a large number of steamers to oil burners; secondly, the wider use of electricity as a power and for domestic purposes; and, thirdly, the increased cost in the market price of coal to the consumers. It seems to me that those who are entrusted with the management of coal mines should consider whether better methods cannot be adopted so as to reduce mining costs, and at the same time provide a better class of coal for marketing purposes. One of the matters that should be attended to as promptly as possible is to see that the working faces in coal mines are properly prepared, and that more

skill is exercised in shooting the coal. It is also important to keep the coal to be marketed as free from stone and other impurities as possible.

CO-OPERATIVE EXPERIMENTS.

Realising that the present system of employing miners and others in coal mines had not been working as smoothly as could be desired, arrangements were made by my authority to work three portions of the State collieries under co-operative agreements. Two of the sections so worked were isolated from other portions of the State collieries, but the third and remaining section formed a part of the James Colliery. One of the sections was worked under the co-operative system for a period of about six months, and the other sections for shorter periods. The results obtained demonstrated clearly that the men obtained material benefits when compared with what they would have gained under the old system, and that such benefits were obtained by the good spirit and fine team-work that prevailed in carrying out mining operations. It was also manifest that under the co-operative principle the relationship established between the men and the department's officials was of a most cordial nature. One and all concerned did their best to make the new system a success; but unfortunately those members of the Miners' Union who were not working on a co-operative system went out on strike as a protest against portions of the mines being worked under such a system, and by pressure from them the members of the co-operative parties were compelled to cancel their contracts with the department, thus bringing to a termination for the time being an honest and earnest endeavour to better the conditions of the miners employed at the State collieries.

CROWN COAL LEASES.

Since the inception of the coal mining law in this Dominion leases conferring the right to work coal on Crown land and other lands where the coal is reserved to the Crown have been granted on recommendation by the Warden or Commissioner of Crown Lands, as the case may be, to persons who had complied with the preliminary conditions of the law. Under this system it has been possible for persons to obtain leases who had insufficient capital to instal up-to-date and sufficient plant to carry on coal-mining operations efficiently. It was also possible for the coal-bearing lands owned by the Crown to be grid-ironed. In the Consolidated Coal Mines Act of last session provision was made with the object of

limiting the number of leases which any person may hold, and also conferring upon the Minister of Mines a measure of control as to the boundaries of such leases. I now think, however, that, having regard to the present state of the coal-mining industry and the requirements of posterity, the time is soon approaching when it will have to be seriously considered whether further leases or coal prospecting licenses should be granted until such time as the demand for coal makes it necessary in the public interest to permit of additional mines being opened upon Crown lands to supply the increased demand.

HOUSING PROBLEM.

One of the most serious causes of discontent amongst coal miners is the fact that housing conditions in several of the mining townships are far from satisfactory. Realising the position, I have from time to time taken the matter up with colliery proprietors. I have made strong representations in such cases with the object of providing better housing facilities; and I am pleased to say that the companies concerned have arranged to make improvements. Still, there is ample need for further work in this direction, and for assisting in providing for social amenities in coal-mining centres. There is no adequate reason why coal-mining townships should not have environments conducive to contentment and happiness.

HELPING GOLD MINING.

I desire to remind you that the Government has by statute and by regulations provided a scale of financial assistance for aiding the gold mining industry which is not excelled in any other part of the world. Opinions are divided as to the need for granting monetary assistance for prospecting or developing particular mines. On several occasions the Government has been asked to grant financial aid to reopen a mine which had not been worked for some years. One school of thought considers that mines should not be reopened unless the prospects are such that the cost will be repaid out of dividends without the aid of a Government subsidy or loan; but there is another school of thought which considers that the Government should unhesitatingly grant aid for reopening such mines. Personally, I do not think Government money should be used for this purpose. If mining companies set up a reserve fund there should be no reason to ask assistance in this respect, as mines could then be thoroughly worked out.

OIL PROSPECTING.

I observe that several of the papers to be read at this conference refer to oil. It is absolutely essential that before embarking upon extensive boring operations for oil the services of skilled and experienced oil geologists are engaged for the purpose of determining as reliably as possible that the prospects are such as to justify the raising of capital, which should be adequate; that suitable plant is installed, and that expert drillers are engaged to control such boring. My earnest hope is that the efforts which are now being made to find a payable oil field in the Taranaki and Gisborne districts will be successful, as this would be of great benefit, not only to this Dominion, but also to the British Empire—particularly during time of war.

There are other forms of mining which deserve encouragement by this conference. A company has been formed to work the iron deposits at Onakaka, Nelson Province. The company has erected an up-to-date plant, and is turning out pig-iron of a very high grade. I trust the iron foundries of New Zealand will use that iron, and so assist in the development of this very important new primary industry. There is also some platinum mining on the south coast of Southland. Let us hope the venture will be successful.

In conclusion, I again desire to express my hearty appreciation of the honour of having been chosen as patron of this conference, and to express the sincere hope that your deliberations will not only be beneficial to this Dominion, but also to the British Empire as a whole. I also trust that arrangements will be made to hold another conference in a few years' time, as I believe that such a conference would be of benefit to the industry. I have now much pleasure in declaring the conference to be opened. (Applause).

GOVERNMENT RECEPTION.

The Minister invited all the delegates and their wives and daughters to attend a reception which he is holding on behalf of the Government that evening in the Government Reception Room at the Exhibition.

On the motion of Mr W. A. Flavell, seconded by Mr W. F. Sligo, a hearty vote of thanks was accorded the Minister by acclamation.

APOLOGIES.

The President announced the following apologies:—

Sir James Allen, K.C.M.G., cabled, "Much appreciate my election as a Vice-President of Mining Conference. I have pleasant recollections of work done by last conference, and wish you every success on this occasion."

Institution of Mining and Metallurgy, London.—The apology cabled to the Hon. Secretary by Sir Thomas Holland, President, and Mr Walter McDermid, Secretary, contained a kind reference to himself which Professor Park said he appreciated very highly. He asked the Secretary to read it.

Professor Waters accordingly read the cable, which ran as follows: "The Council of the Institution of Mining and Metallurgy deeply regret they cannot send special delegate to Mining Conference. They send warmest greetings to conference, and congratulate it on choice of President. Professor Park commands the affectionate respect of British mining profession. Cordial greetings." (Applause.)

Australasian Institute of Mining and Metallurgy (Melbourne).—The Secretary (Mr D. Stirling), on behalf of the Council, cabled as follows: "Council Australasian Institute of Mining and Metallurgy sends greetings and best wishes for success of conference."

Mr Frank Merriks, a past-President of the Institution of Mining and Metallurgy (London), in writing, said: "I hope that the Conference will be successful. I am sure it will be, and I express regret at not being able to attend it. These mining conferences held in different parts of the Empire do an enormous amount of good."

Other apologies received were from the following:—The Secretary for Mines, Melbourne; the Secretary for Mines, Hobart; the Under-Secretary for Mines, Perth; Mr A. Montgomery, State Mining Engineer, Perth; Jas. Bishop (Auckland), N. D. Cochrane (Auckland), E. W. Spencer (Reefton), R. A. Stewart (Waiuta), G. W. Lowes (Reefton), P. N. Kingswell (Auckland), A. H. P. Moline (New Plymouth), Chas. N. Taylor (Gisborne), Messrs C. W. Washbourne, Miller, Whitney, MacPherson, Cole, Hunt, Fyfe, and Strong (Gisborne), Fred G. Clapp (New York), J. A. McEwin (Waiuta), C. E. Richards (Alexandra), E. E. A. Leach (New Plymouth), J. J. W. Lee (Reefton), J. Macintosh Bell (Toronto), Arthur R. Andrew (London), T. R. Hogg (Wai-

uta), Robt. Speight (Christchurch), J. A. Bartrum (Auckland), R. A. Farquharson (Somaliland), Jas. Carruthers (Milton), N. K. Sligo (Dunedin), G. M. Powell (Westport), J. A. Heskett (Onakaka), Fred G. Dunn (Christchurch), W. Cummings (Pullar), George Bennett (Millers Flat), Jas. H. Evans (Macraes Flat), G. Cruickshank, S.M. (Invercargill), H. Dixon, S.M. (Dunedin), H. F. Marriott, and G. J. Binns.

The President then called upon Mr H. L. Tapley, M.P., Mayor of Dunedin, to extend to the visitors a welcome to the city.

The Mayor said that it gave him very great pleasure to extend to the delegates a very warm and sincere welcome to Dunedin. He had all the more pleasure in doing so since they had present amongst them some notable visitors from across the Tasman Sea—Mr Kenyon (engineer to the State Rivers and Waterways Board, Victoria), and Mr Mance (Under-Secretary for Mines, New South Wales). It was a great compliment to any conference held in the Dominion when delegates were sent across the Tasman Sea to take part in its deliberations. (Applause.) He quite appreciated the fact that the Conference could not but be of great value to the Dominion, and to other parts of the British Empire, and he had listened with great interest, as all of them had done, to the very illuminating address given by the Minister of Mines. He was sure that many commercial gentlemen, outside mining altogether, would also appreciate the thorough grip the Minister had shown of the important department he controlled, and the sound advice he had given to those engaged in the mining industry. (Applause.) The Mayor expressed the hope that the delegates, in any spare time they might have, would take the opportunity of visiting the Exhibition, and of seeing something of the scenic beauties of the city and its environs, so that they would realise that Dunedin was a place worth coming back to. He was glad to note that they were to visit Waipori on Saturday next. Not only would they see some very beautiful scenery there, but they would also have an opportunity of inspecting a very fine hydro-electric station. When the Waipori dam was completed it would form a huge lake with a coastline of ninety-five miles. The city, unfortunately, had had to eliminate some mining areas in carrying out the hydro-electric scheme, and that had caused some heart-burning. But the City Council, of course, had to look to the greatest good of the greatest number. They would be interested to know that the old mining village of Waipori would be submerged under some twenty-five feet of water by the lake thus formed. He

again extended a hearty welcome to the delegates, expressing the hope that the Conference would prove fruitful in every possible way, that their stay would be a pleasant one, and that they would all carry away with them very happy recollections of their visit. (Loud applause.)

On the motion of Mr Robert Lee, seconded by Mr R. T. Stewart, a hearty vote of thanks was accorded his Worship.

Notice was then given that during the afternoon only those interested in metalliferous mining were to be present, owing to the annual meeting of the Coal Mine Owners' Association taking place.

The Conference then adjourned to meet in the same place at 2.30 p.m.

WEDNESDAY, 2.30 P.M.

The metalliferous section of the Conference met in the Allen Hall, the President in the chair, when the following papers were laid on the table and discussed:—

1. "On Prospecting and the Revival of Metal Mining in New Zealand," by J. F. Downey, Inspector of Mines. (See page 279.) For discussion, see page 319.

2. "The Auriferous Beaches of the West Coast, with Notes on their Formation, Past Workings, and Future Exploitation," by G. M. Powell, Westport. (See page 167.)

In the absence of Mr Powell, the Chairman laid this paper on the table, and thanked Mr Powell for his paper.

3. "The Auriferous Conglomerate or Cement of the Tuapeka District, Otago New Zealand," by Wm. R. Smythe, Mine Manager, Lawrence. (See page 185). For discussion, see page 339.

4. "New Zealand Iron Industry," by J. A. Heskett, Onakaka. (See page 243.)

In the absence of Mr Heskett, manager of the Onakaka Iron and Steel Co., Mr J. R. Leggo (Chairman of Directors). After a few members had spoken (see page 341), Mr Heskett was accorded a vote of thanks.

5. "Notes on the American Type of Dredge Operating at Rimu Flat, Hokitika District," by J. F. Downey, Inspector of Mines, Reefton. (See page 145.) For remarks, see page 325.

Mr Downey was thanked for his paper, and Mr S. W. Ford, Manager Rimu Flat Gold Dredging Co., was thanked for the facilities he had given Mr Downey to get information for the preparation of his paper.

Remits under Section B of remits (see page 359), were then discussed.

The remits considered were those numbered B1 and B2. For discussion, see page 359.

The meeting adjourned at 4.30 p.m.

In the evening the Hon. the Minister for Mines entertained the delegates and their wives in the Government Pavilion at the New Zealand and South Seas Exhibition. After supper speeches were given by the Minister and Professor Park. The latter proposed a vote of thanks to the Minister for his hospitality, which was carried with much applause.

THURSDAY, FEBRUARY 4, 1926.

The full Conference met at 10 a.m., with Professor Park in the chair.

Papers laid on the table were as follows:—

1. "The Present Position of the World's Oil Shale Industry," by Jas. Park, Otago University. (See page 1.)

The President was given a hearty vote of thanks for his paper.

2. "Some Essentials for Successful Oil Development," by Fred G. Clapp, New York. (See page 63.)

In the absence of Mr Clapp, Mr A. H. Kimbell, at Mr Clapp's request, laid the paper on the table.

After remarks (see page 327), a vote of thanks was accorded Mr Clapp for his paper.

3. "New Zealand Legislation dealing with Petroleum and Natural Gas Production," by A. H. Kimbell. (See page 11.)

After short discussion (see page 342), Mr Kimbell was thanked for his paper.

4. "Short Account of the Search for Oil in Egypt," by H. T. Ferrar. (See page 79.)

5. "Sections of Coal Measures, Kaitangata Coal Field," by M. Ongley, New Zealand Geological Survey. (See page 83.)

"A Section of the Coal Measures and Associated Beds in the Western Part of Huntly Coal Field, Waikato, Auckland," by J. Henderson, New Zealand Geological Survey. For discussion, see page 342.

6. "Ohai Coal Field, Southland, New Zealand," by G. S. Langford and J. T. Mosley. (See page 87.)

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Messrs Langford and Mosley were thanked for having prepared this paper, being the first record of the Ohai Coal Field.

7. "Protection of Underground Roadways," by E. S. Wight. (See page 107.)

For discussion, see page 328.

8. "Spontaneous Combustion and Underground Fires in Coal Mines—Causes and Methods of Dealing with the Same," by Wm. Carson and F. Carson. (See page 111.)

Discussion on this paper was interrupted by adjournment of the Conference at 12.30 p.m.

The members of the Conference were then photographed in the University grounds.

THURSDAY, 2.30 P.M.

The full Conference met in Allen Hall, with the President in the chair.

It was agreed that in order to expedite the work of the Conference it now divide into two sections, one on coal mining, and the other on metalliferous mining, the coal mining section to meet in the School of Mines Lecture Hall under the chairmanship of Mr W. A. Flavell.

The Conference consequently divided into two sections.

COAL MINING SECTION.

Discussion was continued on Messrs W. and F. Carson's paper until the meeting adjourned at 4 p.m.

METALLIFEROUS SECTION.

Chairman: Professor Park.

Consideration of remits under Section B was continued. The remits taken being B3 and B4 on pages 361 and 364. Meeting adjourned at 4 p.m.

AFTERNOON TEA.

At 4 p.m. members of Conference and their lady friends were entertained at afternoon tea in Allen Hall.

FRIDAY, FEBRUARY 5, 1926.

The Conference again met in sections, the Metalliferous Section in the School of Mines and the Coal Mining Section in Allen Hall.

METALLIFEROUS SECTION.

Chairman: Professor Park.

Papers laid on table:—

1. "The Trend of Gold Mining Legislation in New Zealand," by Robert Gilkison. (See page 267.)

For discussion, see page 329.

2. "Big Blasts with Well-Drill Holes and Tunnelling," by J. R. Leggo. (See page 219.)

3. "The Mining Industry of New Zealand—State Aid to, and Revenue Therefrom," by A. H. Kimbell. (See page 311.)

CONSIDERATION OF REMITS UNDER SECTION B.

Remit B4 was further considered, and also Remits B5 and B6, all being finally dealt with. (See discussion on Remits.)

The Metalliferous Section adjourned at 12.30 p.m. to meet in Allen Hall at 2.30 p.m.

COAL SECTION.

FRIDAY, FEBRUARY 5, 10 A.M.

Chairman: Mr W. A. Flavell.

Discussion on Messrs W. and F. Carson's paper was continued and completed.

Papers laid on table:—

1. "The Electrification of the Denniston Collieries, New Zealand," by J. C. Brown. (See page 91.)

2. "The Lubrication of Mine Equipment," by J. C. Leitch. (See page 229.)

Mr Leitch was accorded a vote of thanks for his paper.

3. "Investigations on the Briquetting of New Zealand Coals," by W. H. A. Penseler. (See page 121.)

For discussion, see page 353.

CONSIDERATION OF REMITS, SECTION C (COAL MINING).

Remit C1, relating to safety measures in coal mining, was considered.

The Coal Section adjourned at 12.30 p.m., to meet again at 2.30 p.m.

FRIDAY, FEBRUARY 5, 2.30 P.M.

The full Conference met in Allen Hall, the chair being taken by Professor Park, and the papers read were:

1. "Boiler Water," by D. B. Waters. (See page 197).

For discussion, see page 338.

2. "Mining Education on the West Coast, South Island, New Zealand," by J. F. McPadden. (See page 305.)

For discussion, see page 357.

3. "Clay Resources of New Zealand," by W. Donovan. (See page 259.)

For discussion, see page 358.

CONSIDERATION OF REMITS.

Discussion on Remit C1 was continued, then Remits C2, C3, C4, C5, were dealt with.

The Conference adjourned at 4 p.m. until 5 p.m. to accept an invitation to afternoon tea as the guests of the Directors of the New Zealand and South Seas Exhibition at their reception room in the Exhibition.

The Conference resumed at 5 p.m., and considered remits under Section A. The whole of these, A1 to A8, were dealt with.

A vote of thanks to the President and Secretary was carried, and the Chairman declared the Conference closed.

DINNER TO DELEGATES.

On the evening of February 5 the delegates were entertained at dinner at the Grand Hotel. Professor Park presided, Mr A. H. Kimbell (Under-Secretary for Mines, New Zealand) being at his left hand, and Mr F. C. Mance (Under-Secretary for Mines, New South Wales) at his right. Also at the head table were the Hon. W. H. McIntyre, M.L.C., Mr T. W. Rhodes, M.P., Colonel W. D. Holgate, Mr E. G. Banks, and Mr W. A. Flavell. Apologies for unavoidable absence were received from the Mayor (Mr H. L. Tapley, M.P.) and Mr James (general manager of the State mines).

The loyal toast having been duly honoured Mr J. Loudon proposed the toast of "Parliament." Expressing regret at the absence of the Minister of Mines (the Hon. G. J. Anderson), Mr Loudon said that he fully agreed with him that before any of the shares in mining enterprise were put on the market every investigation should be made in regard to its prospects. (Applause.) They in Dunedin were very proud of their own Minister (the Hon. W. Downie Stewart), and they greatly regretted he could not be present. They were also proud of their Mayor, Mr H. L. Tapley, M.P. They owed a great deal to Parliament, and no member of the Legislature had done more for the mining industry, which was also represented by the Hon. Mr

McIntyre and Mr T. W. Rhodes, M.P., than had their member for Central Otago, Mr J. Horn, M.P. (Applause.) The Parliament of New Zealand would compare favourably with any Parliament in the world. (Applause.)

The Hon. W. H. McIntyre and Mr J. Horn briefly and suitably responded. Mr Horn said that he was sorry to know that while last session they had only four men in the House of Representatives who knew anything about mining, they now had but three. His colleague, Mr T. W. Rhodes, of Thames, had been chairman of the Mines Committee of the House for the last ten years. He was a good chairman, too, and the miners throughout New Zealand had a great champion in Mr Rhodes. (Applause.) He was very sorry that another great champion of miners, Mr Hugh Roland, formerly M.P. for Ohinemuri, was now out of the House. (Applause.)

The Chairman called on Mr Rhodes also to respond, and he did so in a neat speech, assuring those present that a parliamentary life was no picnic, as some people considered it, but a very strenuous life. So strenuous that none but a robust man could stand it for long. In New South Wales Parliament held day sittings, and he wished that we could do the same here. But they had to hold their committee meetings in the morning to consider petitions and so forth, and that often took them till lunch time, and after that they had the afternoon and evening sittings of the House.

THE MINING INDUSTRY.

The President, in proposing the toast of the "Mining Industry," said: In this remote Dominion, where mining is now completely overshadowed by agriculture, it is difficult for the average citizen to realise that in the British Empire, taken as a whole, mining is still the dominant primary industry. In 1924 the total value of the coal, iron, gold, silver, copper, tin, lead, zinc, petroleum, phosphates, gems, etc., raised within the Empire exceeded the total value of the cotton, jute, tea, tobacco, rubber, wool, grain, meat, butter, and cheese more than threefold. Economists and statesmen recognise that the wealth and power of the Empire, its shipbuilding and other great secondary industries owe their existence to the mineral industry. They also recognise that it was their growing production of coal and iron that made it possible for the United States and Germany to challenge Britain's commercial supremacy in the world's oversea markets.

"Since 1853 the mining industry has added £158,000,000 to the wealth of New Zealand, and of that amount gold mining has contributed no less than £95,000,000. The decline of New Zealand's mineral production is a matter of grave national concern; and, with your permission, I will briefly touch on some of the major causes to which this decline may be attributed. First and foremost is the exhaustion of the more easily worked gold deposits. This, of course, was inevitable, for the ground contains but one crop. Then there was the failure to discover fresh ore deposits, this arising mainly from the neglect of mining companies to set aside an adequate proportion of their profits for prospecting and development work.

"Since the war period gold mining has suffered a double handicap in the great increase of wages and cost of mine supplies, and in the fixing of the price of gold at the pre-war rate, notwithstanding the depreciation of the pound sterling. The meaning of this is that miners and companies that were able to make ends meet in 1914 are now unable to continue working except at a loss; or they have to be content with a lower profit than the uncertain nature of the industry warrants. Ore formerly yielding 40s a ton must now yield 65s a ton to put the miner where he was in 1914. Not only in New Zealand, but also in Australia and the United States, all the low-grade goldmines are being closed down. This is specially serious to the Dominion, as we have to export our gold output to pay for the heavy importations of petrol and motor cars from the United States, which refuses to take our raw material in exchange. While on the matter of gold, I may say that New Zealand contains many undeveloped gold deposits of great promise. I need hardly remind you that gold production is of immense importance to the State.

"I now come to coal mining. This branch of the mining industry has not suffered to the same extent as gold mining; but it is not as flourishing as it ought to be, partly because of the heavy importations of overseas coal, and partly because of the increasing displacement of steam by oil and hydro-electric power. Quite recently the Prime Minister stated that the Government had commitments amounting to £10,000,000 in connection with hydro-electric schemes, and the local power boards another £9,000,000, altogether £19,000,000, or, say, with extras, a round £20,000,000, all to be expended within a period of five years. It is evident that hydro-electric energy is going to

become a serious rival to the coal trade. The great convenience, ease of manipulation, and comfort of electric lighting and power are so patent to everybody that hydro-electric schemes have been embarked on without a serious investigation as to whether the same results could not have been obtained at less cost by the use of waste coal. In the United States 75 per cent. of the electric power is steam generated; in Great Britain 95 per cent. In Norway and Switzerland the bulk of the electric power is water-generated, but the obvious reason for this is the total absence of coal in these countries.

COAL IMPORTATIONS CONDEMNED.

"The large importations of coal are undoubtedly having an injurious effect on coal mining. The statements of the Railway Department that it fears a famine of local coal through strikes, and that even if local coal were available it is not suitable for locomotive fuel, are certainly not convincing. If the vast railway systems of Europe and America can be run with coal, surely with a little foresight it should be possible to do the same here. As to the quality of the coal, it ought to be remembered that railway engines can be constructed to use successfully any class of fuel. In my opinion, the Government ought to explore every possible avenue of escape from what is economically an unsound policy, the perpetuation of which penalises both the workers and the employers. The importation of coal is an evidence of timidity. It does not solve the problem, and can only be looked upon as a palliative, affording temporary relief along the line of least resistance.

ONAKAKA IRON WORKS.

"The recent establishment of iron works at Onakaka is a matter for congratulation. In consequence of our isolation and the danger of interruption to our seaborne trade during the clash of the nations, it is of vital importance that the Dominion should produce iron and steel for its own domestic needs, for the maintenance of its secondary industries, and for defence. With splendid vision India and Japan have fostered the establishment of iron works, at a cost amounting to many millions of pounds; while Australia has helped the iron works at Newcastle with liberal bounties. The infant industry at Onakaka will require generous State aid if it is to grow into a useful manhood.

"In New Zealand State aid to agriculture has been on a lavish scale. The sum of £600,000 was paid for a share in the Nauru Island phosphate deposit, involving the Dominion

in an annual interest charge of £30,000 for all time. This big charge was incurred to enable farmers to purchase phosphate manures at a reduction of £2 per ton on pre-war rates, and on a consumption of 100,000 tons a year the Nauru purchase involves an annual cash subsidy of £230,000 to the farmer, apart from all the other costly activities of the Department of Agriculture. As mining men we do not begrudge assistance to the agricultural interests, but we do think that generous assistance should be given to mining, an industry of such far-reaching importance to the Dominion. (Applause.)

AID FOR OIL.

"I am sure you will all agree with me that the discovery of oil in profitable amount would introduce a new industry of immense economic value to the Dominion. Bearing in mind the high cost of boring and the constant risk of failure, I am of the opinion that the Treasury would be well justified in giving development companies of sound standing substantial State aid." (Applause.)

Colonel Holgate and Mr E. G. Banks responded, the former endorsing strongly Professor Park's condemnation of the importation of coal for railway purposes, and the latter declaring that he believed that the gold mining industry could be revived to a considerable extent if the proper steps to that end were taken. They were all agreed upon the importance of the industry, and the question was how best it could be revived. There was no doubt, to his mind, that thorough prospecting would result in important finds being made; but the great trouble was that the speculative mining public had been so frequently sold in past years by schemes that proved unsuccessful—and, he might say, by schemes that never should have been launched—that to-day it was a difficult matter to raise the necessary capital either to carry on prospecting operations or to carry on mining enterprises that had some hope of success. He was confident, however, that if the Government would only adequately aid and encourage prospecting, and help them to put down wild-cat schemes, there was still a great future before the industry. (Applause.)

On behalf of the Coal Mine Owners' Association Colonel Holgate heartily thanked the President of the Mining Conference. The Conference, he said, had been very instructive and interesting, and he was sure that it would prove very beneficial to all those who had attended it, and to the mining industry generally. (Applause.)

The toast of "The Mines Department" was proposed in a eulogistic speech by Mr J. R. Leggo, and responded to by Mr Kimbell.

Mr W. A. Flavell proposed the health of "Our Guests," which was responded to by Messrs F. C. Mance, A. S. Kenyon, and M. Paul; and the toast of "The Press" was given by Mr W. F. Sligo.

Mr E. G. Banks proposed the toast of the President. He himself was an old student of Professor Park, who, he said, had taken a prominent part in New Zealand mining for over forty years, and possessed the warmest esteem of every mining man. The toast was drunk with musical honours and great applause.

A very enjoyable musical programme, several items in which were heartily encored, was contributed by Messrs J. A. Haggitt, H. McAllum, G. J. Errington, Butler, P. S. M. Sinclair (vocalists), and Mr W. H. A. Penseler (violinist).

PRESENTATION TO PROFESSOR WATERS.

On behalf of the Executive and the delegates of the Dominion Mining Conference, Professor Park, in a very eulogistic speech, presented Professor Waters (Secretary to the Conference) with a handsome smoker's cabinet, as a token of their esteem and regard. The smoothness of the arrangements and freedom from hitch of any kind were a tribute to their Secretary's fine staff work. The health of Professor Waters was drunk with musical honours and great enthusiasm. Professor Waters responded, and heartily thanked Professor Park and members who, during his illness, had taken much work off his shoulders. He also thanked the Mine Owners' Association for consenting to hold their annual meeting in Dunedin at the same time as the Mining Conference, all the delegates who had read papers, and all others who had helped to make the Conference such a success. (Applause.)

The singing of "Auld Lang Syne" and the National Anthem brought a very pleasurable function to a close.

THE PRESENT POSITION OF WORLD'S OIL-SHALE INDUSTRY.

JAMES PARK, Otago University.

The production of natural oil has nearly reached the possible maximum, and in a few years will probably begin to show a sensible decline. On the other hand, the consumption of oil is rapidly increasing, and already threatens to outstrip the production.

At the present time new sources of possible oil supply are being investigated at great cost in America, Europe, and the Far East. The lessons of the Great War have not been lost, and almost every country is taking stock of its oil-shale resources with a view to the producing of its own domestic supply of oil against the day when the present generous supplies of well-oil shall become depleted. Improved methods of distilling oil-shale are being introduced, and there is good reason for the belief that in the near future there will arise a demand for oil derived from bituminous shale by destructive distillation. It is fortunate that oil-shales are almost as widely distributed as coal. Many of the known shale deposits are of vast extent, and the working of them at a profit is purely an economic problem. The gradual exhaustion of natural oil will bring about a corresponding increase in the market price of both crude oil and petrol, and eventually a point will be reached that will permit shale-oil to be put on the market at a profit. The rise of the shale industry and decline of the petroleum production will be slow, and though marked by rivalry the success of the shale-oil industry will be brought about at first by the quiet penetration of the local markets. The heavy transport charges will be a serious hindrance to the challenge of shale-oil in foreign markets for a considerable time to come.

Oil-shale deposits have now become a national asset of immense potential value.

United States.—The oil-shale deposits of Wyoming are of great extent and value. They are members of the Green River formation of Eocene age, and occur mainly in the Sweetwater and Uintah counties. Forty samples taken by the United States Geological Survey gave on distillation about 16 gallons of oil and 6lb of ammonium sulphate to the ton, from beds averaging four and a-half feet in thickness. It should, however, be noted that samples selected from the same deposits by the Wyoming Geological Survey gave results ranging from 23 to 40 gallons of oil from shale beds ranging from 15ft to 60ft thick.

The Utah deposits, like those of Wyoming and Colorado, form a part of the Great Western oil-shale field. They are of vast extent, and contain some of the richest shales in America. They include the Naval Oil-shale Reserves set apart by Congress in 1916, the shales of Uintah Basin, Soldier Summit, Watson, and White River. An elaborate system of sampling by the United States Geological Survey has shown that an oil content of 42 gallons to the ton may be obtained from a thickness of shale ranging from 20ft at Soldier Summit to 60ft in the Uintah Basin.

The total amount of oil in the Utah oil-shales is estimated at over 23,350,000,000 barrels. If allowances equal to 50 per cent. are made for a possible thinning of the shale beds due to the intercalation of clay-shale bands, for the grade of the oil-shale being lower when mined on a large scale than in the test samples, and for the losses incurred in distilling, the possible yield of oil compares favourably with the yield from any known oilfield.

The Colorado oil-shales are a continuation of the Wyoming shale measures. They are of great importance, and include a Naval Oil Reserve of 45,444 acres and the large holdings of the Ventura Colorado Oil Company in the De Beque district. This company has recently completed a plant for the production of oil from a shale yielding 60 gallons to the ton. The estimated costs of mining are 90 cents a ton, crushing 6 cents, retorting 13 cents, or a total cost of 1.09 dollars a ton. According to the Colorado

State Immigration Bureau, the sum of £1,000,000 is about to be directly and indirectly expended in the development of the shale industry in Colorado. The work already done includes road and camp-making, erection of machinery and experimental retorts, opening up the shale deposits, State and private experimental tests.

The Naval Oil-shale Reserve in Colorado comprises 45,444 acres, and in Utah 91,464 acres, or in all 136,908 acres. It is estimated by Victor C. Alderson that if only 100,000 barrels are produced from each acre there is a potential supply in the Naval Reserves alone of nearly 14,000,000,000 barrels of oil.

The Paleozoic oil-shale deposits in Ohio, Indiana, and Kentucky comprise what is known as the Great Eastern oil-shale field. Generally the oil content is lower than in the Great Western field, but against this may be set the advantage of cheap mining, better transport facilities, nearness of market, and an abundant water supply.

Oil-shale beds of great extent occur associated with the Carboniferous coal measures of Pennsylvania, but they are very low grade and unlikely to become an available source of oil for some considerable time.

In Jackson County, Oregon, an oil-shale bed 16ft thick is being worked by private enterprise. The shale lies near the surface, and is being mined with steam shovels.

At Carlin, in the state of Nevada, shale-oil is being successfully produced on a commercial scale from a shale bed reported to be in places 300ft thick. The deposit extends through two counties. The mining costs amount to about a dollar a ton. The shale yields about 38 gallons of crude oil per ton, and the products of the plant—gasoline, kerosene, lubricating oil, and paraffin wax—find a ready sale in competition with well-oil. The lubricating oils have been found to be specially useful for aeroplane and automobile use. The plant handles about 100 tons of shale a day. The Carlin retort now in use was adopted after trial on a commercial scale with five different processes. The retort belongs to the vertical type. It is a circular steel shell lined with fire-brick, and divided into three horizontal sections from top to bottom, comprising the distillation, fire, and ash zones. The capacity is 80 tons in one charge.

The shale is crushed to two-inch size, and fed in at the top. When once charged and lighted the process is continuous. As fast as the oil and gas vapours are produced in the distillation or topmost section, the carbon residue drops to the middle or fire zone, which furnishes by circulating gas the heat for distillation in the zone above. The combustion of the carbon is controlled by the amount of oxygen in the gas. The spent shale from the fire zone drops to the ash zone below and is discharged. The oil vapours from the top zone go to the condensing plant, from which the uncondensable gases are carried back to the fire zone, and there provide heat for distillation.

The oil-shales of California are of vast extent, and occur in the Monterey stage of the Middle Miocene, in an established petroleum oilfield. In Santa Barbara county they are commercially valuable, though as yet undeveloped.

Canada.—Large deposits of oil-shale occur in New Brunswick, Nova Scotia, and Newfoundland. The D'Arcy Exploration Company, said to be a subsidiary offshoot of the Anglo-Persian Oil Company, erected an experimental retort of the Wallace type at Rosevale, and operated it for nine months. The average yield was 37 gallons of oil and 60lb of ammonium sulphate to the ton, but owing to the high cost of labour and supplies it has been decided to postpone the erection of a large commercial plant.

Great Britain.—The oil-shale deposits of the Lothians of Scotland are of considerable extent, but generally the oil content is not high. The Broxburn shales are of medium grade, yielding from 24 to 30 gallons of crude oil and 40lb of ammonium sulphate to the ton, while the shales of Drumshoreland give about 20 gallons of oil and 60lb of ammonium sulphate. For many years the Scottish oil-shale industry has been maintained by the production of valuable by-products. In Scotland the mining and retorting of oil-shale has been carried on for over half a century, and it was there that the refining of crude oil was perfected, long before the discovery of natural oil in America.

Oil-shales occur in Norfolk, Somerset, and Devonshire, but contain such a large proportion of sulphur, usually from 5 to 8 per cent., as to make the resulting oil unmarketable.

A recent appeal for money to carry out experimental work at the University of Birmingham on the oil-shales of England led to the contribution of £122,000. Results having an important bearing on the commercial treatment of the shales are confidently expected.

France.—The bulk of the oil-shales of France occur in the Aunance, Manosque, Frejus, Faymoreau, Vagnas, Vendes, and Autunois districts. The available amount is estimated at 50,000,000 tons, more than half of which lies in the Autun basin. The Var Oil and Coal Company is successfully operating a retorting plant with a capacity of 200 tons of shale a day.

Sweden.—Oil-shale beds of great extent and value occur at Kinnekulle, where a plant has been erected capable of an annual production of crude oil that it is believed will make Sweden independent of imported petroleum and its derivatives. The high ash content of the shale presents a difficulty that will add somewhat to the cost of production.

Spain.—An oil-shale plant has been for several years in successful operation at Puertollano, 110 miles south of Madrid. The products find a ready local market. The shale occurs in a bed 6ft thick, and it yields about 30 gallons of crude oil to the ton. The retorts are of the Scotch vertical type, of small capacity and slow acting.

Italy.—An area of 500 acres of oil-shale country is being worked between Ragusa and Syracuse, Sicily. The oil produced is of good quality, and the bitumen is used for asphalt paving, while the lubricating oils supply the domestic demand. Undeveloped areas of oil-shale also occur on the mainland at Lombardy, Venetia, and Calabria.

Esthonia.—Oil-shale of good grade occurs over a great part of Esthonia, and steps are now being taken to develop it on a large scale. The deposits dip gently to the south from the shore of the Baltic Sea to Narva. Over extensive areas they lie under a thin cover of overburden ranging from 6ft to 16ft thick, and it is proposed to mine the shale with steam shovels. Cunningham-Craig estimates that after allowing for the cost of mining, retorting, and general

cha; there will be a net profit of about twenty shillings a ton. Already a large amount of raw oil-shale is being used on the Esthonian railways and in factories. The amount of shale that may be easily mined is estimated at 1,500,000,000 tons. The oil-shale industry of this country, though only in its infancy, has already made great progress. The production of oil-shale increased from 9500 tons in 1919 to 208,000 tons in 1923. The estimated output for 1924 is 400,000 tons. The Government works at Kothla already employ 1500 men. The cost of open cut mining averages about 84 cents a ton, exclusive of royalty and overhead charges. It is estimated that underground mining will cost 20 per cent. more.

Concessions in the Vaivara and Vanamoisa districts, amounting in all to 265,000 acres, have been granted by the Esthonian Republic to groups of Swedish and English financiers. Under the terms of agreement the Government receives 5 per cent. on all oil produced and 10 per cent. of the shale mined.

According to Professor Helmersen the composition of Esthonian oil-shale is as follows:—

Volatile substances	...	...	...	70.96
Coke	...	...	...	11.08
Ash	...	...	...	18.86
				100.00

Japan.—Throughout its whole extent the coal in the Fushan basin is overlain by oil-shale. To get the coal the shale must be removed, so that the economic conditions for successful oil production are extremely favourable. It is estimated that the shale bed will yield 1,900,000,000 barrels of oil, or enough to meet the needs of the Japanese navy for 300 years or more. Extensive experimental work on this shale has already been carried out in Manchuria by Professor T. Kimura, and a commercial test of 500 tons was made at Pumpherston, Scotland. The results were considered satisfactory, and arrangements have now been made by the South Manchurian Railway and the Japanese Government to erect a plant with a capacity of 2000 tons of shale a day. The estimated cost of the work is—

Distillation plant	...	...	...	£360,000
Refinery	...	...	...	150,000
Miscellaneous	...	...	...	90,000
				£600,000

The estimated costs of treatment per ton of shale are.

Retorting	...	...	...	...	...	\$0.71
Refining	...	...	...	...	...	0.92
Sulphate of ammonia	...	...	...	...	...	0.45
Disposal of residue	...	...	...	...	...	0.20
						\$2.28

The market value of the products is estimated at \$3.12 a ton, which leaves a gross profit of 84 cents a ton for a plant treating 2000 tons of shale a day. After allowing for depreciation, and for the balance between mining costs and the value of the spent shale, the profit is estimated at 13 per cent. on a capital expenditure of £600,000.

It is evident that Japan is fully alive to the importance of possessing an independent supply of oil for her navy and rapidly expanding industries.

Burma-Siam.—A bed of oil-shale 6ft thick has been proved to extend in the oil region over an area two miles long and a quarter of a mile wide. The proved quantity of shale is estimated at 13,500,000 tons, and the average yield of crude oil amounts to 33 gallons to the ton. Of this quantity 7,500,000 tons gave on analysis an average yield of 45 gallons of oil and 48lb of ammonium sulphate to the ton. A serious hindrance to the development of this potentially valuable shale deposit is the poor transport facilities. The production of the Burma oil-wells is unable to supply the local demand. The products of the experimental Crozier retort at Wembley Exhibition showed that this oil-shale is capable of yielding high-grade lubricating and paraffin oils.

New South Wales.—Oil-shale occurs at many places in the upper coal measures (Permian), and also at Greta and the head of the Clyde Valley in the lower coal measures, and perhaps with one exception the shale outcrops occur near the edge of the coal basin.

Typically the shale occurs in irregular seams and lenticular patches, merging, as a rule, at the edges into bituminous coal or ordinary clay-shale. Beds of oil-shale, mostly thin, occur intercalated with seams of bituminous coal as at Joadja Creek.

The principal oil-shale deposits occur at Mount Kembla, near Woollongong, Hartley Vale, near Mount Victoria, and Joadja Creek, near Mittagong.

The upper bed of shale at Hartley Vale is about four inches thick, and yields 40 gallons of crude oil to the ton, and the lower bed, 3ft thick, yields from 60 to 80 gallons to the ton.

The mining of oil-shale began in New South Wales in 1865, and the total output up to 1924 was 1,500,000 tons, valued at about £3,000,000. Works for the production of oil were erected at Hartley Vale, but owing to the high cost of mining the enterprise did not meet with much success. Nevertheless the oil-shales of New South Wales are a valuable asset to the State.

Tasmania.—Oil-shale of good grade has been proved to underlie an area of 300 square miles, extending from Latrobe in the north to Minrow and Quamby Bluff in the south, a distance of 30 miles. The estimated quantity of oil-shale is 43,000,000 tons, with an average yield of 40 imperial gallons to the ton. A large area has been reserved for the use of the State, but some concessions have been granted to public companies, and with Government aid it is believed a valuable industry will soon be established.

New Zealand.—Oil-shale deposits occur in Middle Tertiary rocks at Awatere, Mongonui County, Auckland; at Waitati, near Dunedin; at Waikaka and Orepuki, Southland.

The composition of the Awatere oil-shale approximates that of the torbanite of Scotland, and is as follows:—

Volatile hydrocarbons	...	...	...	75.20
Coke	...	...	...	9.30
Hydroscopic water	...	...	...	1.80
Ash	...	...	...	13.70

100.00

There is only a trace of sulphur.

The extent of this valuable oil-shale is at present unknown.

The bed of oil-shale at Waitati is of great extent, and ranges from 4ft to 12ft thick. It is low grade, the yield of crude oil averaging about 20 gallons to the ton. The ammonium sulphate content is also low.

The oil-shale bed at Orepuki averages about 4ft thick, and has been proved by borings to extend over a large area. Its average composition is as follows:—

Volatile matter	...	...	...	...	40.40
Coke	...	...	...	...	14.60
Water	...	...	...	...	5.70
Ash	...	...	...	...	39.30

100 00

About twenty-five years ago the Kaitangata Coal and Oil Compnay erected a retorting and refining plant at Orepuki, but owing to the high cost of mining and treatment the oil products could not be placed on the market at a price to compete with the products of well-oil. Meantime the plant has been closed down. The yield of crude oil amounted to about 40 gallons, and of ammonium sulphate 26lb to the ton of shale.

Owing to its isolation it would be sound statecraft on the part of the New Zealand Government to take stock of the Dominion's potential oil resources by the carrying out of detailed geological surveys, and encourage the production of oil to supply the domestic requirements.

South Africa.—There is a bed of torbanite in the Ermelo district, Transvaal, reputed to be the richest oil-shale in the world. It occurs in thin beds, extends over an area of 40 square miles, and is estimated to contain at least 25,000,000 tons of shale, yielding from 80 to 100 gallons of oil to the ton. The crude oil produces 20 per cent. of gasoline of the best quality. An experimental Griffith retort has been erected at Johannesburg, and is working successfully on Ermelo torbanite. This retort is of the horizontal revolving type, 13½ft long and 6in in diameter, with a heating length of 10½ft. It treats 240lb an hour, and

yields at the rate of 75 gallons of crude oil to the ton. A special feature is a metallic brush inside the retort which circulates the shale, scrapes the interior, and prevents caking. This type of retort seems to be best suited for the treatment of high-grade shale.

Chili.—The discovery of a large area of good grade oil-shale has been reported at Chucumata, a small seaport 24 miles south of Iquique. Many mining claims have been granted, but the importance to be attached to the discovery can only be determined by boring.

NEW ZEALAND LEGISLATION DEALING WITH PETROLEUM AND NATURAL GAS PRODUCTION

By A. H. KIMBELL, Under-secretary New Zealand
Mines Department.

The purpose of this paper is to narrate briefly the origin of, subsequent changes in, and the provisions of the legislation governing the prospecting and development of petroleum and natural gas in the Dominion of New Zealand. The first reference to legislation dealing therewith is to be found in Section 3 (3) of the Mining Act Amendment Act, 1892, which provided that the word "mineral" in relation to mining purposes shall be deemed to include petroleum and all other mineral oils. In the Consolidated Mining Acts which were passed in the years 1898, 1905, and 1908 the term "mineral" was defined to include petroleum and all other mineral oils. That definition, in so far as it concerned petroleum and other mineral oils, was repealed by Section 2 (4) of the Mining Amendment Act, 1911, it having been found by experience that the general provisions of the Mining Act, 1908, were too unwieldy and in part inapplicable to prospecting and mining for petroleum and other mineral oils. Instead of passing a special Act dealing with petroleum the Government of the day made provision in Section 2 of the Mining Amendment Act, 1911, empowering the Governor-General from time to time by Order-in-Council gazetted, to declare that any of the provisions of the Mining Act, 1908, shall apply to prospecting and mining for and the storage of petroleum and other mineral oils and of natural gas; to define the district within which any such Order-in-Council shall take effect; and to make regulations for the efficient control of operations in connection with prospecting or mining for and the storage of mineral oil and natural gas, and for the prevention of unnecessary waste thereof. By virtue of such authority the

following Orders-in-Council were made and gazetted, declaring that certain sections of the Mining Acts and regulations gazetted thereunder were to apply to parts of what were believed to be petroliferous bearing lands in the Dominion:—

ORDERS-IN-COUNCIL.

<i>Date of Order-in-Council.</i>	<i>Date published in New Zealand Gazette.</i>
April 30, 1912	May 9, 1912
August 5, 1912	August 8, 1912.
November 29, 1912 . . .	December 5, 1912.
September 22, 1913, as amended by Order-in-Council of November, 24, 1913	September 25, 1913, and November 27, 1913, respectively.
March 25, 1915	April 1, 1915
July 12, 1915	July 15, 1915
July 29, 1919	August 7, 1919
March 9, 1921	March 18, 1921.
October 22, 1924	October 23, 1924

A recent and close scrutiny of the provisions contained in such Orders-in-Council disclosed important omissions and impracticable conditions. In order, therefore, to put the matter on a better and sounder basis, the whole of the provisions of the Mining Act, 1908, and the large number of amendments of that Act were carefully reviewed, with the result that all the previous Orders-in-Council were revoked and a fresh Order-in-Council was gazetted (Gazette No. 71 of October 15, 1925), declaring that the following provisions of the Mining Act, 1908, and its amendments and the regulations gazetted thereunder shall be applied to prospecting and mining for and the storage of petroleum and other mineral oils, and of natural gas within the districts described in the Order-in-Council—namely:

THE MINING ACT, 1908

Part I.—Section 4: Definitions of Crown lands, Endowment, Land, Minister, Native, Native land, Native ceded land, Native reserves, Occupier, Owner, Person, Private lands, Public Reserve, Unalienated Crown land; Section 7.

Part III.—Section 20.

Part IV.—Sections 76 to 79, 80 (1), 81 to 85 (both inclusive), 95, 113, 154, 165, 166, 168, 171, 172, 173, 179; 205, 207, 209, 212 (a) (b) (c) and (e), 213, 214 to 222.

Part V.—Sections 243, 245 to 247, 254 (37), 261, 262, 263, 265 to 273 (both inclusive), 275, 276

Part IX.—Sections 310, 321, 322, 323, 324, 325, 326 to 330

Part XII.—Sections 392 (1) (2) (13) (33) (34) (36) (40) (43), 402

The Mining Amendment Act, 1910 —Sections 5, 15, 19 (i) (t) (u)

The Mining Amendment Act, 1911 --Section 3

The Mining Amendment Act 1914 —Sections 13, 15, 17, 18, 24, 30

The Mining Amendment Act, 1919 —Sections 10, 11

The Mining Amendment Act 1920 —Sections 5, 11, 12

The Mining Amendment Act 1922 - Sections 2, 11, 13

The Mining Amendment Act, 1924 —Section 6

Regulations 1, 10, 15 to 17, 19, 21, 33, 34 to 37, 57, 68 to 75, 77, 79 to 85, 91, 124, 147 to 152, 156, 169, 170, as published in New Zealand Gazette No 93 of August 5, 1915

Regulation 76, as published in New Zealand Gazette No 128, of November 16, 1916

Regulations 193 to 301a, as published in New Zealand Gazette No 99, of November 24, 1921, and as amended by Regulations published in New Zealand Gazette Nos 2 and 12, of January 15, 1925, and February 19, 1925, respectively

Regulation 37, as published in New Zealand Gazette No 103, of December 15, 1921

The districts defined within which such Order-in-Council is to be applied are fully described in the second schedule thereto

A further Order-in-Council, containing the same provisions as those referred to in the two last preceding paragraphs, and applying to the survey districts of Tutamoe, Tokomaru, Waikohu, and Patutahi, situate in the Gisborne Land District, was gazetted on October 22, 1920.

The law as now applied by such two last mentioned Orders-in-Council may be described briefly as follows:—

THE MINING ACT, 1908.

Part I.—Section 4: So many of the definitions as applied to petroleum have been incorporated in the Order-in-Council—viz: Crown lands, Endowment, Land, Minister, Native, Native land, Native ceded land, Native Reserves, Occupier, Owner, Person, Private lands, Public Reserve, Unalienated Crown land.

Section 7 provides that Proclamations, Orders-in-Councils, Orders, Rules, Regulations, or Gazette notice as may be made from time to time may apply in any manner, partially or generally, in relation to matter, person, time, or place, and may be altered, revoked, or cancelled.

Part III, Section 20, as amended by Section 3 of the Mining Amendment Act, 1922, provides that State Forests and Scenic Reserves shall be subject to the provisions of the Mining Act, 1908, relating to mining on Crown lands, subject to Section 35 of the Forests Act, 1921-22, as to timber cutting rights.

Part IV, Section 76, as amended by Sections 3 of the Mining Amendment Act, 1911, and by Section 12 of the Mining Amendment Act, 1920, provides for the granting by the Warden within a mining district or the Commissioner of Crown lands outside a mining district, with the consent in writing of the Minister of Mines, of a warrant (defined as "a Mineral Prospecting Warrant") authorising the holder to prospect for any specified mineral or minerals over any Crown or other lands specified in the warrant not exceeding an area of 10,000 acres. A deposit of £50 for the first thousand acres, with an addition of £25 for every thousand acres or part thereof applied for in excess of one thousand acres, has to be made with the application. In respect of any land other than Crown land, the issue of the warrant is subject to the written consent of the owner and lessee, if any.

Section 77 provides that a Mineral Prospecting Warrant shall, unless previously cancelled under Section 79, continue in force for a period of five years from the date on which it was granted.

Section 78 provides that the holder of any such warrant shall, while it continues in force, have the exclusive right to prospect for the mineral or minerals specified in the warrant, and may enter upon such land for that purpose.

Section 79 provides that every Mineral Prospecting Warrant shall be held under such conditions as to employment of labour and development of the mine as may from time to time be prescribed by regulations, and that it may at any time be cancelled for the non-observance on the part of the holder of any such conditions

Section 80 (1): At any time while a mineral prospecting warrant is in force the holder shall, on complying with the provisions of those parts of the Act which were incorporated in the Order-in-Council under Section 2 of the Mining Amendment Act, 1911, have the right to a mineral lease of such part of the land to which the warrant relates not exceeding one thousand acres, and in one continuous block, as he may select.

Section 81 empowers the Governor-General to make regulations by Order-in-Council prescribing the rent and royalty payable, and the labour and other conditions under which any Mineral Prospecting Warrant or Mineral Lease shall be granted; providing for the refund from time to time of sums (not exceeding in the whole the amount deposited with the application) in proportion to the amount spent in complying with any such labour or other conditions; and prescribing the terms and conditions on which licenses or warrants may be issued and the amount that shall be expended each year in prospecting under any such license or warrant.

Section 82 reserves the right of the Warden or Commissioner of Crown Lands to grant licenses or warrants for prospecting for gold or other metal or mineral, etc., over any part of the land which may be leased for another mineral, such as the production of petroleum, provided that the holder of petroleum rights will not be prejudiced thereby

Section 83 empowers the holder of a Mineral Prospecting Warrant or of a mineral lease to obtain any mining privilege for gold or any other metal or mineral over any part of the lands specified in the warrant or lease.

Section 84 provides that, subject to the provisions of Sections 76 to 85 of the Mining Act, 1908, the provisions

of that Act, relating to prospecting warrants or licenses, and to mineral licenses shall, so far as applicable, apply to mineral prospecting warrants and mineral leases.

Section 85 provides that the powers conferred under Sections 76 to 84 of the Mining Act, 1908, on a Warden or Commissioner of Crown lands may be exercised by the Governor-General in respect of Native lands.

Section 95 provides that every person by whom any claim or other mining privilege is lawfully taken up, and every person lawfully deriving through him shall, according to his share and interest therein, be deemed to be the holder thereof until it is forfeited or abandoned.

Section 113 defines the procedure which is to be followed where compensation is to be determined by the Warden and Assessors.

Section 154 provides the machinery as to surrender, exchange, and amalgamation of mining privileges, provided that the surrender shall not in any way release the holder from liability for all sums owing in respect of rents, fees, royalty, etc.

Section 165 specifies the general rules in respect to every application to the Warden for the grant, surrender, exchange, amalgamation, or protection of mining privileges, or, in the case of a claim, for authority to employ less than the prescribed number of workmen.

Section 166 prescribes that powers and functions conferred by the Mining Act, 1908, upon the Warden and Registrar respectively for receiving and disposing of applications for prospecting warrants, prospecting licenses, etc., shall, where the land is outside a mining district, be exercised by the Commissioner of Crown Lands; but such power does not apply in the case of Native land or of land partly within and partly outside a mining district.

Section 168: Surveys are not required where the whole of land applied for is included in Crown grant or land transfer certificate of title, unless the Warden specially orders that to be done, etc.

Section 171: Every mining privilege shall be deemed to be a chattel interest, and may be sold, encumbered, transmitted, seized under writ of execution or warrant, or otherwise disposed of as fully as a chattel interest in land, subject nevertheless to the provisions of the Mining Act, 1908.

Section 172 provides for the registration of transfers of any mining privilege, and for the conditions subject to which such may be done

Section 173 requires the Warden, when granting or renewing any license, to transmit the instrument of license or renewal to the Registrar for registration and issue, and the Registrar is required, after endorsing thereon a memorial of every registered instrument affecting the same, to issue it to the person entitled to receive it.

Section 179 provides for the payment of the prescribed fee for registration of instruments (see Regulation No. 84 referred to hereafter)

Section 205 requires the consent of the local or other authority having the control of any road or street where the holder of a mining privilege desires to exercise upon, over or under any public road or public street, any of his rights as such holder.

Section 207 provides that, except where otherwise provided by the Mining Act, 1908, every person who by reason of his mining operations causes damage to land shall be liable to pay compensation for such damage to the owner and occupier of such land, and such compensation shall be assessed in the manner prescribed by Section 113, which has been mentioned previously herein.

Section 209 provides that, in assessing the compensation payable by the holder of a mining privilege to any person, compensation already received shall be taken into account, so that the claimant shall in no case be entitled to compensation more than once in respect of the same matter.

Section 212—(a) (b) (c) and (e): The holder of a mining privilege is not entitled to valuation or compensation from the Crown in respect of buildings, machinery, and other structural or non-structural improvements made by him, but the holder at any time before the expiration of the prescribed period after he ceases to be the holder may remove or otherwise dispose of all structural improvements belonging to him and being on the land; provided that such right of removal shall not exist in the case of timber and other materials actually used and applied in the construction or support of any shaft, drive, gallery, adit, tunnel, race, dam, or other mining work existing on the land. If

he removes any such timber or other materials in breach thereof he is liable to a fine not exceeding £100. The prescribed period is specified as 30 days after he ceases to be the holder of the mining privilege. Except as already mentioned, no person shall have any right or title to any improvements on the land comprised in any mining privilege after he ceases to be the holder thereof.

Section 213: All wages payable to the workmen employed at any mine shall, if so requested by a majority of such workmen, be paid either at the mine or at some place not more than two miles from the mine

Section 214 provides that every person who is employed by the holder of a mining privilege to work thereon on wages or on contract shall have a lien on such mining privilege for wages or contract moneys owing to him by such employment extending to three months, wages to a wages man and to £100 in the case of a contractor or sub-contractor. The wages man has priority

Part IV, Section 215, provides that a duly registered lien for wages or contract moneys shall have priority over all other then existing or subsequently created encumbrances, liens, or interests whatsoever affecting the mining privilege to which such registered lien relates

Section 216 as amended by Section 19 (i) of the Mining Amendment Act, 1910, empowers the Warden to determine all questions relating to liens, and to allow costs

Section 217 empowers the Warden to make an order on the application of the lienee causing the mining privilege to which the lien relates to be sold by public auction, provided that the application of the lienee is made within three months after the registration of the lien or within such further period not exceeding three months as the Warden may allow, and that due notice of the application has been given to the holder of the mining privilege

Section 218 prescribes how the proceeds of the sale of the mining privilege are to be applied, and also empowers the Warden to execute transfer of privilege

Section 219 empowers the mortgagee of a mining privilege which has been ordered to be sold to satisfy the liens.

Section 220 provides how the moneys paid by the mortgagee are to be applied.

Section 221 provides that the term "mining privilege" as mentioned in Sections 214 to 220, both inclusive, shall include all plant and machinery situate on or worked in connection with a mining privilege and belonging to the holder thereof.

Section 222 provides that in so far as may be prescribed by Regulations under the Mining Act, 1908, 'The Wages Protection and Contractors' Liens Act, 1908,' shall not apply to any lien

Part V, Section 243, prohibits the employment of any skilled or unskilled manual labour on Sundays, except in cases where the previous authority in writing of an Inspector of Mines has been obtained

Section 245 gives the right of appeal to the Warden from a decision of any Inspector of Mines in respect of the granting or refusal of an authority to work on Sundays

Section 246 provides that if any workman is employed in breach of Section 243 the person or company employing him and also, where the employer is a company, the mine manager and every director thereof are severally liable to a fine not exceeding £5, provided that if the Court is satisfied that the employment was rendered necessary by reason of breakage or other special emergency involving danger to life or damage to property such shall be regarded as a sufficient defence to a prosecution

Section 247 The operations of Section 17 of the Police Offences Act, 1908, are not affected by Sections 243 to 246 of the Mining Act, 1908

Section 254 (37) as amended by Section 19 (q) of the Mining Amendment Act, 1910, provides that every steam boiler shall be provided with a proper steam gauge and water gauge, and also with a proper safety valve. Every boiler shall be thoroughly cleansed and once in every twelve months shall be subjected to an hydraulic test. The date and full description of every such test and cleansing is to be entered in a book kept by the mine manager or other person in charge, and the entries in such book shall on demand be open to the perusal of any Inspector of Mines or to any Inspector under the Inspection of Machinery Act, 1908

Where compressed air is used as the motive power for any machinery the air receiver or air pipe shall have a pres-

sure gauge so fixed that the engine-driver shall have an uninterrupted view of the pressure gauge.

Section 261 empowers an Inspector of Mines to give notice to the person in charge of the mine of dangerous or defective matters which, in his opinion, threaten or tend to the bodily injury of any person, and the case is not elsewhere sufficiently provided for by any express provision of so much of the Mining Act, 1908, as is applied to the production of petroleum.

There is a right of appeal from the requisition of the Inspector of Mines to the Warden, who may by order confirm, reverse, or modify the requisition as he thinks fit. If the owner fails to comply with the requisition or order, and such failure continues for 14 days after the expiration of the time for objection or after the date of the order, he commits an offence, but if the Court is satisfied that the owner has taken active measures for complying with the requisition or order but has not with reasonable diligence been able to complete the works it may adjourn such proceedings, and if the works are completed within a reasonable time no fine shall be inflicted.

Section 262: All employees are required to report unsafe appliances or dangerous matters to the person under whose immediate direction or control they may be. Every person is required to satisfy himself of the safety of the appliances he may have to use, and shall refrain from using anything which is unsafe. Every person in sub-charge of and employed in mining operations shall on changing his shift inform the person appointed to relieve him of the state of the workings in which he has been employed.

Section 263: The Inspector of Mines is required thereunder to make inquiry into the matter of any complaint by any person employed in a mine, without divulging the name of the informant.

Section 265: Every person who by himself, his agent, or servant is guilty of negligence by which any person is injured or killed commits an offence.

Section 266 as amended by Section 17 of the Mining Act, 1914: Where in the opinion of the Inspector of Mines an accident in a mine resulting in the death or injury of any person was caused directly or indirectly by the non-observance by the mine manager, etc., of the mine of any

provisions of the Mining Act, 1908, or of any regulation thereunder, or by reason of his negligence, the Inspector is required to apply to the Warden to hold an inquiry into the matter. The person whose non-observance or negligence is to be inquired into has to appear at the time and place fixed by the Warden and to produce his certificate to the Court. The Court consists of the Warden sitting with two Assessors appointed by the Warden, one of whom shall be the holder of a first-class certificate as a mine manager and who has been actually engaged as such, and the other shall be a workman selected by a society of workmen formed in connection with the mining industry. If the Court finds that the accident was caused directly or indirectly by the non-observance by the holder of any certificate under the Act or any provisions thereof, or of any regulation thereunder, or by reason of his negligence it may disqualify him, cancel his certificate, or suspend it for such period as it thinks fit. There is a right of appeal against the order of the Court as if it were an order of the Warden and the appeal would have to be heard by a Judge of the Supreme Court. Notice of any disqualification requires to be published in the Gazette.

Section 267 provides that any accident occurring in a mine shall be *prima facie* evidence that such accident occurred through some negligence on the part of the owner.

Section 268: If any person employed suffers any injury in person, or is killed owing to the non-observance of any of the provisions of the Mining Act, 1908, such non-observance not being solely due to the negligence of the person so injured or killed, or in any way to the negligence of the owner of the mine, his agents, or servants, the person so injured, or his personal representatives, or the personal representatives of the person so killed, may recover from the owner compensation by way of damages as for a tort committed by such owner. The amount of such compensation with the costs of recovering the same shall constitute a charge on the mine and mining plant in or about which such person was employed. The compensation may be recovered under the provisions of the Workers' Compensation Act, 1922, or the Death by Accident Compensation Act, 1908, whichever is applicable, according to the circumstances of each particular case, but nothing in Section 268 shall take away from any person any right to take pro-

ceedings in respect of a claim for compensation for injury or death by accident which he may have under any Act other than the Mining Act, 1908. if he prefers to proceed under such Act, but in such case he shall forfeit any right he may have to take proceedings under that Section.

Section 269 as amended by Section 19 (t) of the Mining Amendment Act, 1910, and Section 11 of the Mining Amendment Act, 1922, defines the procedure which must be followed when an accident occurs in a mine.

Section 270 specifies that no person having a personal interest in or employed in or in the management of a mine in which an accident has occurred shall be qualified to serve on a jury empanelled on the inquest. Disqualified persons are not to be summoned to appear, and it is the duty of the Coroner not to allow any such person to be summoned or sit on the jury. Whenever practicable one-half of the jurymen shall be miners.

Section 271 defines the duties of the Inspector of Mines, one of which duties requires him to see that the provisions of the Mining Act, 1908, are complied with, and to visit and inspect mines and all machinery, etc.

Section 272 Where it appears to an Inspector that any sanitary defect in a mine may be more effectually remedied or dealt with by the District Health Officer, he is required to give notice thereof to that officer, who shall thereupon take such measures as may be necessary to effectually remedy the defect.

Section 273 provides that the powers of the Inspector of Machinery under the Inspection of Machinery Act, 1908, are not affected by the provisions of the Mining Act, 1908.

Section 275 provides that every person who in any way contravenes or fails to comply with the provisions of Part V of the Mining Act, 1908, is liable to a fine not exceeding £50 if he is convicted in the capacity of owner or mine manager, underground manager, or person in charge of or giving orders or directions relating to the carrying on of any mining operations, and every person who contravenes that part of the Act if he is convicted in any other capacity than as aforesaid is liable to a fine not exceeding £10.

Section 276: If the fine has reference to an offence by reason whereof any person is injured or killed, the whole or any part of such fine may, by the convicting Court, be awarded to such person, or, to his personal representatives.

Part IX, Section 310, provides that the proceedings for the recovery of fines shall be taken in a summary way in the Warden's Court before the Warden alone.

Section 321 provides machinery in respect of encroachment suits. The Court is empowered on application to authorise any person to enter on any land, mine, etc., for the purpose of ascertaining whether any encroachment exists.

Section 322 provides when such powers of the Court as mentioned in the preceding section may be exercised.

Section 323 defines the general powers of the Court to enforce contracts or award damages, etc

Section 324 defines how judgments and convictions may be enforced by the Warden

Section 325 specifies by whom warrants of the Court may be served.

Section 326: No proceedings shall be dismissed or vitiated because of informality. In every instance the proceedings shall be amended by the Court so that the actual subject-matter in dispute may plainly appear and be adjudicated upon according to the substantial rights of the parties

Section 327 provides for recording and formal drawing up of judgments by the Warden or Clerk of the Court

Section 328 specifies the mode of service of injunctions or other orders.

Section 329 confers additional powers upon the Warden so that he may exercise all the powers of the Supreme Court or a Judge thereof.

Section 330 defines the machinery under which orders of the Court may be enforced by inflicting fines and otherwise.

Part XII, Section 392 (1) (2) (13) (33) (34) (36) (40) (43), as amended by Section 11 of the Mining Amendment Act, 1919. Regulations may be made: (a) Under paragraph (1) prescribing the rights, duties, powers, and functions of the Warden or any officer or other person appointed under the Mining Act, 1908, or employed or acting in the administration thereof and of the districts wherein he shall exercise the same; (b) under paragraph (2) for

the efficient management and administration of affairs of the mining districts; (c) under paragraph (13) prescribing the terms, conditions, and restrictions subject to which prospecting operations may be carried on, the mode of assessing the amount of compensation payable by the prospector to the owner or occupier of the land prospected on, etc.; (d) under paragraphs (33) (34) and (36) fixing the fees to be paid in respect of Court proceedings, prescribing the costs that may be awarded, the scale of allowances for witnesses' expenses, and the procedure in specified cases, including claims for damage done to land by reason of prospecting operations; and (e) under paragraphs (40) and (43) for the compilation of mining statistics and requiring from the holders of mining privileges all such particulars as may be prescribed, and also prescribing the respective forms of licenses, etc., that may be issued, the mode of recording same, etc

Section 402 empowers the Receiver of Goldfields Revenue for a mining district or the Receiver of Land Revenue for a land district to sue for the recovery of fees, rents, royalties, and other dues payable

THE MINING AMENDMENT ACT, 1910

Section 5 empowers the Warden to direct that the land comprised in any claim shall be surveyed in the prescribed manner, and also authorises him to direct that the cost or estimated cost of the survey shall be deposited in the Warden's Court by the person on whose application the order is made; the time within such survey shall be completed is three months, or within such extended time as the Warden allows

Section 15 provides that all applications for mining privileges shall be finally heard and decided by the Warden within six months from the date of the application, but under special circumstances the Warden may, with the consent of the Minister, extend the time within which an application may be heard

Section 19 (i) provides for the payment of costs in addition to the amount of the lien, or the wages due under a lien as a condition precedent to the discharge of the lien.

Under paragraph (t) (bb) of Section 19 as amended it is provided that every accident connected with the winding arrangements and every case of over-winding whether attended by person injury or not shall be reported forthwith to the Inspector of Mines by the mine manager or other person in charge.

Under paragraph (u) of Section 19 as amended the Inspecting Engineer of Metalliferous Mines, or other officer of the Mines Department who is authorised in writing by the Minister, may at any time enter and inspect any mine

THE MINING AMENDMENT ACT, 1911

Section 3 extends the scope of Section 76 of the Mining Act, 1908, by empowering the Warden to grant to any person a warrant (a mineral prospecting warrant) authorising the holder to prospect for any specified mineral or minerals only not over Crown lands, but other land, provided that no such warrant shall be issued with respect to any land other than Crown land unless the consent in writing of the owner or lessee, if any, of the land has been obtained and is produced to the Warden or Commissioner of Crown Lands

THE MINING AMENDMENT ACT 1914

Section 13 amends Section 261 of the Mining Act, 1908. The amendments are not important and do not need description.

Section 15 is an important section, as it empowers an Inspector of Mines when he is of opinion that a mine or any part thereof or any practice therein is immediately dangerous to life, he may cause the person in charge of the mine to withdraw the workmen therefrom, except such workmen as are required to effect the necessary work to put the mine in a safe condition, or he may cause the said practice to be discontinued. Mining operations shall not, save in pursuance of an order by the Warden, be resumed until the Inspector of Mines has certified that the mine or part thereof has been made safe to his satisfaction or that such practice has been discontinued. The person in charge of the mine upon receipt of notice from the Inspector is required to take active steps to comply therewith, in default whereof he is liable to a fine not exceeding £100

Any owner, agent, mine manager, or person in charge of a mine who directs or wilfully allows mining operations or any practice to be resumed or continued in breach of Section 15 is liable to a fine not exceeding £100 for every day or part of a day on or during which such operations or practice shall be resumed or continued. If the owner objects to comply with the terms of the notice there is a right of appeal to the Warden, who is required to investigate and to determine the question at issue.

Section 17 repeals Sub-section 4 of Section 266 of the Mining Act, 1908, and there is substituted a provision providing that an inquiry as to accidents shall be held before a Court consisting of the Warden sitting with two Assessors, both appointed by himself, one of whom shall be the holder of a first-class certificate as a mine manager, and who has been actually engaged as such, and the other shall be a workman selected by a society of workmen formed in connection with the mining industry.

Section 18 extends the provisions of Sections 275 and 276 of the Mining Act, 1908, to offences under the Amending Act with respect to the working, regulation, or inspection of mines

Section 24 makes it mandatory that it shall be the duty of the Inspector of Mines to prosecute all persons who are reasonably believed to have committed any serious breach of the Mining Act, 1908, the Mining Amendment Act, 1914, or of any regulation made thereunder respectively, unless the Inspector is satisfied that the appropriate proceedings in respect of the same breach have been instituted and are being duly carried on by some other person empowered in that behalf. No person may be punished twice for one and the same offence

Section 30 empowers the Registrar to revise the register of mining privileges in cases where he has reason to believe that the mining privileges are not being worked. The procedure is largely availed of in respect of mining privileges relating to mining for other than petroleum

THE MINING AMENDMENT ACT, 1919

Section 10 amends Section 261 of the Mining Act, 1908, relating to requisitions for remedy of dangerous matters in mines. The amendments are of a machinery nature and do not need explanation

Section 11 amends and extends the requirements of Section 392 as to the compilation of mining statistics.

THE MINING AMENDMENT ACT, 1920.

Section 5 extends further the provisions of Section 266 of the Mining Act, 1908, so as to empower the Court to make such order as to the payment of the costs of the inquiry, provided for under that Section, etc.

Section 11 amends Section 20 of the Mining Act, 1908, by adding thereto a reference to the Scenery Preservation Act, 1908, and also adding reserves. The consent of the Minister charged with the administration of the Scenery Preservation Act, 1908, has to be obtained to the granting of a license or other mining privilege affecting scenery reserves.

Section 12 has already been referred to in connection with Sections 76 and 78 of the Mining Act, 1908.

THE MINING AMENDMENT ACT, 1922.

Section 2 provides for making regulations prescribing for the payment of fees where the approval of the Minister of Mines has to be obtained to the exercise or performance of any power or duty by a Warden or Commissioner of Crown Lands under the Mining Act, 1908. (For regulation see Gazette No. 66 of October 1, 1925.)

Section 11 specifies that where an accident causes loss of life to any person or causes any fracture of the head, or of any limb, or of any other serious personal injury to any person, the mine manager or other person for the time being in charge shall forthwith by telegraph give notice of such accident to the Minister of Mines, the Warden, the Inspector of Mines, and the workmen's Inspectors, and in addition he shall give to the Inspector in the prescribed form written notice of such accident.

Section 13 makes slight verbal alterations to Section 30 of the Mining Amendment Act, 1914, and do not need any explanation.

THE MINING AMENDMENT ACT, 1924.

Section 6 provides that licenses for dams cannot be granted by the Warden without the consent of the Minister of Mines.

REGULATIONS INCORPORATED IN ORDERS-IN-COUNCIL.

The Orders-in-Council not only apply certain provisions of the Mining Acts to prospecting and mining for and the storage of petroleum, but also incorporates certain of the Regulations dealing generally with mining, and in order that this paper may be complete, a brief resume of such Regulations is given hereunder (Gazette No. 93 of August 5, 1915):—

Regulation 1 provides that words and expressions in the Regulations shall have the same meaning as in the Mining Act and its Amendments. It also provides that all references in the Regulations to the Warden or Registrar shall to a limited extent be deemed to be references to the Commissioner of Crown Lands and the Receiver of Gold Revenue respectively.

Regulation 10 provides that in the case of prospecting warrants or licenses relating to other than Native land the application shall be dealt with under such of the provisions of Section 165 of the Mining Act, 1908, and the Regulations relating thereto, as are applicable.

Regulation 15: The rent payable under a mineral prospecting warrant shall be 1d per acre per annum for the first two years, 2d per acre per annum for the third year, 3d per acre per annum for the fourth year, and 6d per acre per annum for the fifth year.

Regulation 16: The rent payable under a mineral lease, granted under Section 80 of the Mining Act, 1908, shall be 2s 6d an acre, or part of an acre, per annum, but should the prescribed royalty exceed the amount of rent in any one year such rent shall for that year cease.

Regulation 17 provides that the royalty payable under a mineral lease shall be one-twenty-fifth of the value of the mineral at the pit's mouth, and such value shall be fixed before the lease is issued.

Regulation 19: The holder of a mineral prospecting warrant is required to transmit to the Inspector of Mines every six months a statement of the amount expended during the preceding six months, together with a short report of the nature of the prospecting operations. The statement as to expenditure requires to be verified by statutory declaration. Copies of such statements and reports also require to be forwarded to the Minister of Mines.

Regulation 21 provides for refunds of the amount deposited by an applicant for a mineral prospecting warrant or mineral lease in sums of not less than £50 on the certificate of an Inspector of Mines that all the requirements of the Mining Act and Regulations have been complied with, and that at least £100 has been expended in prospecting or the development and working of the lands comprised in the mineral lease for every £50 applied for as a refund.

Regulation 33 prescribes the general rules which shall be observed in respect of every application to the Warden under Section 165 of the Mining Act, 1908. As the rules are fairly extensive they are not repeated in this paper, but may be referred to in the Gazette mentioned above.

Regulation 34 provides that the Regulations for the time being in force relating to block and section surveys under the Surveyors' Institute and Board of Examiners, Act, 1908, shall be deemed to be incorporated with and subject to the Regulations under the Mining Acts.

Regulation 35 empowers the Warden at his discretion to order the land to which an application relates to be surveyed notwithstanding that the area does not exceed 20 acres.

Regulation 36 specifies in detail the requirements which must be made in making the survey.

Regulation 37 prescribes the general rules which shall apply with respect to surveys. (For amendment, see Gazette No. 103 of December 15, 1921.)

Regulation 57 prescribes the procedure for the surrender of mining privileges, whether absolutely or for purposes of exchange of title or amalgamation of claims.

Regulation 68 prescribes the form of and how the register which requires to be kept by a Registrar or Receiver of Gold Revenue shall be divided into parts, etc.

Regulation 69 provides for keeping alive registers which were in existence when the Mining Act, 1908, came into force.

Regulation 70 prescribes that the office of registration shall be the office of the Registrar as provided by Section 173 of the Mining Act, 1908, etc., etc.

Regulation 71 prescribes that the registration of an instrument shall not be deemed to be invalid by reason merely of being effected in the wrong office, unless the Warden is satisfied that it has resulted in deceiving any person and thereby actually prejudicing his rights.

Regulation 72 requires that all instruments shall be registered in the order in which they are deposited for registration.

Regulation 73 prescribes that for the purpose of Regulation 72 an application under Clauses 77 or 78 of the Regulations shall be deemed to be an instrument

Regulation 74 prescribes that the instrument registered or a duplicate original or certified copy shall be retained and filed as a record by the Registrar, and for that purpose the original must be accompanied by such duplicate original or certified copy.

Regulation 75 provides how the registration of an instrument shall be effected.

Regulation 77 prescribes the procedure to be followed as to the registration of mining privileges held otherwise than under license.

Regulation 79 prescribes where instruments or applications require to be lodged, and during the hours as defined in Regulation 120 (daily from 10 a.m. to 1 p.m. and from 2 p.m. to 4 p.m., except on Saturdays, Sundays, and holidays; on Saturdays from 10 a.m. to 12 noon).

Regulation 80 provides that the Registrar shall not register any mining privileges, or lien, or any instrument purporting to transfer, or to in any way deal with any mining privilege, except in manner provided by the Mining Act, 1908, and the Regulations.

Regulation 81 requires the Registrar to see that instruments liable to stamp duty are duly stamped before registration by him

Regulation 82 empowers the Registrar to rectify errors in entries in the register or in any memorial.

Regulation 83 requires the Registrar to furnish to any person applying a certified copy of any registered instrument upon payment of the fee of 6d per folio of 90 words. Every document purporting to be certified under the hand of the Registrar and the seal of the Court as a certified copy shall, without proof of his signature, be received in evidence for all purposes for which the original instrument might be put in evidence.

Regulation 84 provides for payment of a registration fee of 1s for each separate registration and for payment of 1s for search fee in respect of first title, and 6d for every additional search made at the same time

Regulation 85 provides that the register may be searched at any time during office hours

Regulation 91 prescribes the terms, conditions, and reservations subject to which every mining privilege shall be deemed to be granted and held. As there are no less than 11 sub-paragraphs, some of which are fairly long, the provisions thereof are not repeated, but may be perused by referring to the Gazette already quoted

Regulation 124 specifies that the fees mentioned in the seventh schedule to the Regulations shall be payable in respect of matters therein mentioned, and that the allowance to witnesses in proceedings in the Warden's Court shall be those specified in that schedule.

Regulations 147, 148, 149, 150, 151, 152 specify as to how service may be effected in connection with the proceedings before the Warden, except in the case of a summons where the mode of service is prescribed by Sub-sections (14) to (19) of Section 333 of the Mining Act, 1908. Where in the case of a summons the defendant is beyond the limits of the Dominion, but has an agent within the Dominion authorised to defend actions, service, may, by leave of the Court, be made upon such agent.

Regulation 156 empowers the Receiver of Land Revenue outside a mining district to exercise the powers and functions of the Receiver of Gold Revenue to the extent prescribed by Section 166 of the Mining Act, 1908.

Regulation 169 specifies what forms may be used under the Mining Act, 1908.

Regulation 170 provides that where the Commissioner of Crown Lands exercises the powers and functions of the Warden it shall not be necessary to seal any license or warrant.

Gazette No. 128 of November 16, 1916: Regulation 76 requires the Registrar in the case of the transfer of a mining privilege or of any interest therein to endorse on the license or document of title a memorial, giving particulars of the transfer, and where the transfer affects any surveyed portion of any surveyed claim he is also required to cancel the plan on the special claim license as to the transferred portion of such claim, and to issue a new license in respect of the portion so transferred.

—Special Regulations Relating to Petroleum.—

Gazette No. 99 of November 24, 1921, as amended by Regulations published in Gazette Nos. 2, 12, and 80 of January 15, February 19, and November 19, 1925. Regulations 193 to 301 (a). As such Regulations are of very important nature they are repeated in full hereunder.

—Definitions.—

193. In this part of these regulations, unless inconsistent with the context,—

“Apparatus” means electrical apparatus, and includes all apparatus, machines, and fittings in which conductors are used, or of which they form a part.

“Authorised person” means a competent person appointed in writing by the well-manager to carry out certain duties.

“Board of Examiners” means the Board of Examiners appointed pursuant to Sections 226 and 227 of the Mining Act, 1908.

“Casing” means the pipe commonly used within wells drilled for natural gas or petroleum.

“Circuit” means an electrical circuit forming a system or branch of a system.

“Conductor” means an electrical conductor arranged to be electrically connected to a system.

“**Earthed**” means connected to the general mass of earth in such manner as will ensure at all times an immediate discharge of electrical energy without danger.

“**High pressure**” means a pressure in a system normally above 650 volts, but not exceeding 3000 volts, where the electrical energy is used or supplied.

“**Inspector**” means an Inspector of Mines appointed under the Mining Act, 1908.

“**Live**” means electrically charged.

“**Mining operations**” and “**mining purposes**” mean boring or otherwise prospecting for natural gas, petroleum, or oil, and drilling, operating, or abandoning a well or spring as herein defined or the refinement of oil produced therefrom, and includes:—

- (a) The storing, conveyance, and treatment of any natural gas, petroleum, or oil, or other similar product.
- (b) The erection, maintenance, and use of machinery and the construction or use of races, dams, channels, tanks, lighters, vessels, pipe-lines, reservoirs, and other works of whatsoever kind connected with any such operations or purposes.
- (c) The deposit or discharge of debris, refuse, and waste products produced from or consequent on any such operations or purposes.
- (d) The lawful use of land, watercourses, water, and the doing of all lawful acts incident or conducive to any such purposes or operations.

“**Oil**” means crude or refined mineral oil and their products, excluding water.

“**Open sparking**” means sparking which, owing to the lack of adequate provision for preventing the ignition of inflammable gas external to apparatus, would ignite such inflammable gas.

“**Pressure**” means the difference of electrical potential between any two conductors through which supply of energy is given, or between any part of either conductor and the earth.

“System” means an electrical system in which all conductors and apparatus are electrically connected to a common source of electromotive force.

“Well” means a borehole drilled for the purpose of developing natural gas or petroleum, or a borehole producing natural gas or petroleum.

“Well-manager” means the person having actual control of well operations.

“Well operations” mean drilling, operating, or abandoning such well as hereinbefore defined, or the refinement of oil produced therefrom, or any mining operations.

“Well-operator” means any legally responsible person, persons, firm, partnership, syndicate, corporation, company, or association that drills, operates, or abandons, or purposes to drill, operate, or abandon, such well as hereinbefore defined.

“Workman” includes every person employed in working for wages, or on contract, on or in connection with any well operations.

—Workmen.—

194. No person under the age of eighteen years shall be employed at well operations.

195. Every workman at well operations shall be supplied by the manager or authorised person with a copy of these Regulations, and shall be warned by such manager or supervisor of the danger of the ignition of inflammable gas or oil.

196. If more than six persons are employed at one time at any well operations there shall be provided near such operations, and not in the engine-house, boiler-house, or any building in which oil is stored or dealt with, sufficient accommodation for enabling the workmen to conveniently wash themselves and to dry and change their clothing

—Officials —

197. On and after the date of the gazetting of these Regulations no person shall be employed to act in the capacity of well-manager and have charge of well operations unless he is the holder of a service permit granted by the Board of Examiners.

198. A service permit shall not be granted unless the applicant satisfies the Board of Examiners that (a) he resides in New Zealand, and that (b) he has had in the aggregate at least three years' practical experience in various capacities at well operations where gas and oil have been dealt with, and that (c) he is a person of ability, sobriety, and good conduct; provided that such Board may, if it thinks fit, waive the requirements specified in conditions (a) and (b) of this Regulation in the case of a borehole which has been drilled in search for coal producing gas. The fee for a service permit shall be £2 2s, and such fee shall accompany each application (as amended in Gazette No 80 of November 19, 1925).

199. The Board of Examiners shall have the power to refuse to grant a service permit or to cancel any permit granted as aforesaid.

200. If a well-manager is at any time *incapacitated* from performing his duties, or is *about to be absent* from the well operations for more than six working days, he or the well-operator shall appoint some person, approved in writing by an Inspector, as *deputy manager* during such incapacity or absence; but no such deputy shall act for more than fourteen working days at any one time, unless authorised to do so by an Inspector.

201. A license to bore for petroleum or other mineral oils or natural gas shall be issued, in the case of Crown lands, only to the holder or holders of a mineral prospecting warrant or a mineral lease granted under the Mining Act, 1908, or, in the case of any lands other than Crown lands, to the owner or owners of the land to which the license shall relate (the word "owner" includes any person or body corporate to whom such owner shall have granted a lease or license to prospect or bore for petroleum or other mineral oils or natural gas) (As amended in New Zealand Gazette No. 2 of January 15, 1925).

202. Application for a license to bore for petroleum or other mineral oils or natural gas shall be addressed to the Minister on the form numbered 117 in the Eleventh Schedule hereto, and shall be accompanied by a fee of £5.

203. The license shall be in the form numbered 118 in the Eleventh Schedule hereto. An owner or operator having obtained a license to drill shall not be under the neces-

sity of confining his operations to one bore, but may drill any number of bores during the currency of his license, provided that Regulations 204 and 205 shall be complied with in respect of each and every bore, and the approval of an Inspector obtained before any bore is commenced

Commencement of Drilling.—

204 The owner, agent, or manager of any well or bore shall, before commencing the work of drilling, give written notice to an Inspector of his intention to drill, and such notice shall contain the following information:—

- (a) Statement of location and elevation above sea-level of the floor of the proposed derrick and drill rig.
- (b) The number or other designation by which such well shall be known
- (c) The owners' or operators' estimate of the depth of the point at which water will be shut off, together with the method by which such shut-off is intended to be made, and the size and weight of casing to be used
- (d) The owners' or operators' estimate of the depth at which oil or gas-producing sand or formation will be encountered.

The foregoing provisions shall also apply so far as may be to the deepening or redrilling of any well, or any operation involving the plugging of any well, or any operations permanently altering in any manner the casing of any well

205. No well shall be drilled within a distance of 132 yards from an adjoining well or within a distance of 66 yards from the nearest boundary of an adjoining property, the mineral rights of which are owned or leased under different ownership. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

—The Surface.—

206. If required by the Inspector, that part of the drilling area containing the derricks and engines and boilers shall be fenced. Sufficient gates shall be provided to give free egress for the workmen in case of emergency, and no timber or inflammable material shall be used in the construction of fences or gates. Holes, abandoned wells, or

other excavations shall be filled up level with the surrounding surface, and, where necessary, shall be protected with a fence 5ft high. The boundaries of unfenced well operations shall be marked in a conspicuous manner. Wells which are only stopped temporarily, water-wells, mud, oil, and residue pits shall be adequately protected.

207. No persons other than those actually engaged therein shall come within the enclosed or fenced portion of well operations.

208. A conspicuous notice board to the above effect shall be continuously exposed at all entrances to enclosed places.

209. Mud and oil from a well shall not be allowed to flow over the surface, but shall be collected in suitably arranged tanks or pits. All tanks or pits for oil, or for mud containing oil, shall be covered with waterproof material and fenced.

210. The boring area shall always be kept clean. The removing of oil from any tank shall be carried out in such a manner that the spilling of oil over the surface of the ground is prevented. The surface earth which has been saturated with oil shall be removed or covered with dry earth.

211. Oil or other objectionable matter shall be prevented from running into rivers or streams.

212. There shall be constructed near the derrick a gas-proof tank or tanks of adequate capacity for oil from outbursts or from well operations where outbursts are probable, and the oil shall be conveyed thereto through iron pipes in such a manner as to prevent loss of oil or pollution of the surrounding surface. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

213. No hot iron, naked light, matches, or other appliance for the production of fire or for smoking shall be taken into the derrick and buildings connected thereto, or into places in which oil is exposed, used, or handled.

214. The use of firearms, the making of open fires, and the stacking of inflammable material shall not be permitted within the fenced area of well operations, or in any building or enclosed places used in connection therewith.

215. No artificial light, other than an electric safety-lamp of type permitted by the Inspector, shall be taken into the buildings where oil is handled, treated, or distilled.

216. There shall be provided and maintained at all productive well operations and in the vicinity of all oil intended for sale or commercial use fire-extinguishing appliances, also shovels, axes, sand, and water, immediately available to extinguish fire. Where steam is available provision shall be made for utilising it readily for fire-extinguishing purposes. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

—Buildings and Installations.—

THE DERRICK AND ADJOINING BUILDINGS AND INSTALLATIONS.

217. The derricks and buildings connected therewith, also the machinery and tools for drilling, shall be of good material and strongly and securely erected. No other building but that covering the drill plant and stationary drilling-engine shall be attached to or in proximity to a derrick.

218. Except with the previous consent of the Minister, timber shall not be used in the construction of any derrick, except for the framework. This regulation shall not apply to the buildings existing at the time these regulations come into operation.

219. The derrick shall be securely guyed by strong wire rope, or otherwise adequately supported

220. Where drilling-rods are used galleries shall be constructed within the derrick, having a railing 3ft high and a footboard. Ladders leading to such galleries shall be of adequate strength, strongly secured, and maintained in good repair. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

221. There shall be provided in each derrick opposite the highest gallery a window which opens to the outside, and in front of this window, on the outside of the derrick, there shall be constructed and maintained a platform having a railing 4ft high, to which suitable ladders shall be connected to provide the workmen engaged in the top of the derrick with adequate means of escape in cases of emergency.

222. The buildings over the drilling plant and machinery shall be of adequate dimensions to allow safe access to all working-places.

223. The floors of the derrick and engine-house shall be sanded, to prevent workmen from slipping.

224. If drilling-rods are placed on a table or rack it shall be provided with an arrangement for preventing them from falling therefrom.

225. Operations at gushing or extremely gaseous wells shall not be permitted unless adequate provision is made for the immediate closing of the well by a blowout preventer or capping, which will also permit the removal of the oil and gases into storage-tanks.

226. All operations to recover lost drilling tools from any well where unusual force is being used in turning the rods or tubes shall be carried out under the direct supervision of the manager. The use of more than one lever fastened to the rods or tubes and the use of keys is prohibited during operations for such recovery. In all heavy and dangerous work with the pulley-blocks, and also during the so-called racing of the engine, the presence in or near the derrick of persons other than the driller and the workmen assigned to the work by the driller is prohibited. The manager shall give great attention to the work when pulley-blocks or screw-jacks are being used. When working with screw-jacks precautions must be taken to prevent the parts from flying about in the event of the breakage of the rods.

227. The walking-beam shall be so balanced that it may be lowered easily by hand after the drilling-rods have been unscrewed. Under the walking-beam on the well side of the drill there shall be fixed a post to protect the workmen in the event of the breakage of the pitman.

228. The brake-bands of the rig shall be of suitable dimensions, and shall be manufactured in such a way that with ordinary care sparks will not be produced. For this purpose the brake-bands shall be lined with vulcanised fibre or other material which will not emit sparks.

Provided that if an iron brake-band be used upon a wooden wheel suitable provision shall be made for an adequate supply of water to be applied to the brake-band. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

229. Tools shall not be raised with a Canadian slipper-out during the movement of the walking-beam. The steel wheel shall be provided with a double dog.

230. No engine other than a stationary engine shall be used when drilling by steam power.

BOILER-HOUSES AND BOILERS.

231 Every boiler-house shall be so situated that the prevailing wind will divert inflammable gas therefrom. Every boiler-house shall be securely roofed with non-inflammable material. This regulation shall not apply to any boiler-houses existing on August 3, 1915.

232 Boiler-houses shall be of adequate dimensions to permit safe and convenient access to all parts of the boiler.

233. Between the firebox and the nearest end of the boiler-house there shall be a clear space of at least 6ft. The floor of the boiler-house shall not be constructed of inflammable material

234. The roof around the boiler-chimney shall be constructed of sheet iron for a distance of 2ft from such chimney. Between the boiler-chimney and the roof of the boiler-house there shall be a sheet-iron pipe, which shall project above the roof. The chimneys of portable boilers shall be at least 26ft high, and of sufficient diameter to allow the escape of smoke. All chimneys shall be provided with approved covers and spark-arresters, which shall be frequently cleaned from soot.

235. In the event of a dangerous outburst of oil or gas the fire in the boiler shall be extinguished as quickly as possible. Withdrawal of the fire is prohibited. Where oil or gas is being used for fuel a throttle valve to control the flow of the oil or gas shall be provided on the pipeline outside of the boiler-house and at least 20ft from the wall thereof. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

236. In the event of an outburst of oil or gas possessing extraordinary force, the well manager, or, if he is not present, the next in authority, shall see that the boiler fire is extinguished, and that such other precautions are taken as are necessary for safety. He shall also immediately notify the Inspector of the occurrence. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

237. Ashes from any ash-box shall be completely extinguished before removal from the boiler-house.

OTHER BUILDINGS AND MACHINERY.

238. Offices shall be provided at all well operations, but the Inspector may, if he considers it desirable, permit one office for several well operations under the same proprietary if such operations are not separated by too great a distance

239 Buildings at measuring-stations shall be at least 33 yards distant from any smithy, boiler-house, dwelling-house, workmen's rooms, offices, or public roads, and shall be adequately ventilated

240 Every oil-pumping station shall be at least 50ft away from any dwelling-house, smith, shop, or public road This regulation shall not apply to any station in existence as at August 3, 1915

241 Every oil-pumping station shall be kept perfectly clean and adequately ventilated

249. Electric installations, when not specially provided for in these regulations, shall be subject to the regulations for the Installation of Electricity, under the Mining Act, 1908.

250. There shall be attached to every gas-engine an automatic starting device.

251. All moving and rotating parts of engines and other machinery, also all steam-pipes and electric current conductors, shall be protected from accidental damage.

252. No inflammable material shall be used for protecting or covering steam-pipes in the vicinity of well operations.

253. All pipe-lines shall be of adequate strength and securely jointed.

254. Workmen employed about the engine shall not wear loose-fitting outer garments.

255. Belts shall not be attached by hands to moving pulleys.

256. No person shall lubricate any machinery while in motion, except when machinery may not be adequately lubricated when stationary.

257. All engines shall be started and stopped with care, and such starting or stoppage shall be indicated by signals which may be seen or heard by the workmen employed thereon

—Oil and Gas Tanks.—

258. Every oil-tank at well operations shall be constructed of fireproof material, and shall be efficiently protected and closed. (As amended in New Zealand Gazette No. 12 of February 19, 1925)

259. Tanks shall be encircled by a high and strong embankment, constructed at an adequate distance from such tank. The open space between embankment and tank shall be kept clean and free from obstruction. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

260. The roof of each tank from which gases are not led away through pipes shall contain a ventilator, which shall be covered with a copper gauze having at least 784 apertures per square inch, or shall be equipped with pressure and vacuum safety valves. The cocks and valves of

the outlets of every tank exceeding 3000 gallons in capacity shall be kept locked. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

261. To all tanks exceeding 16ft in depth there shall be attached a strong iron ladder. If the roof of the tank is convex, access to the manhole shall be secured by means of iron railing. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

262. Every iron tank exceeding 3000 gallons in capacity shall be provided with a lightning conductor, which shall be erected by a competent person.

263. Oil which has consolidated shall be heated with steam only; fire on no account shall be used.

264. A burning tank shall not be extinguished with water, but oil within the tank shall be withdrawn through the outlet-pipes to other tanks or pits. Smaller tanks or barrels, if burning, shall be covered with sand, wet sack-ing, or other suitable material.

265. No oil-tanks exceeding 3000 gallons in capacity shall be constructed or placed within 40 yards of any building containing a fire, or any public road. For any smaller tank the distance shall be at least 20 yards. This regulation shall not apply to any tank in position on August 3, 1915

266. The cleaning of all tanks shall be carried out in the following manner: Wooden oil-tanks and oil-pits shall, after the extraction of the oil, be partially uncovered and ventilated for at least twenty-four hours, and if a steam boiler is available the tank shall be blown out with steam. The cleaning may be proceeded with afterwards, from the outside if possible. If cleaning is indispensable and cannot be done from the outside, unless self-contained breathing apparatus is worn, only one workman shall be employed in any tank at one time, in which case the workman shall be secured by a rope, and shall be attended by a supervisor and another workman.

267. Outlets of adequate dimensions for ventilation shall be placed in the roof and near the bottom of every iron tank. The ventilation and blowing out of every larger tank shall be continued until it is safe for the workmen to enter

268 Every well in which boring has been suspended, and which produces a considerable volume of gas, shall have its outlets so constructed that gas may be conducted therefrom through pipes, provided with suitable valves, and if the gas is issuing from the well at high pressure a proper gas regulator shall be provided (As amended in New Zealand Gazette No 12 of February 19, 1925.)

269 A separate gasometer shall not be compulsory if oil and gas is conducted from a well to a separator which is more than 33 yards from any operative well, building having a fireplace or stove or a public road.

270 If a pipe line connects with a gas-main of equal diameter conveying gas from another gasometer, a separate gasometer is not compulsory.

271 The above regulations do not apply to gasometers which were in existence on August 3, 1915. Gasometers and gas separators shall be of adequate capacity and strength and shall be provided with two approved safety valves.

272 Gas pipes from any gasometer to a boiler shall be free from oil.

273 Every pipe-line connecting any well with a gasometer or separator shall be provided near such gasometer or separator with a valve which shall be closed in the event of the pipe line becoming disconnected.

Heating of Steam Boilers —

274 All gas used for boiler heating shall be dry or free from oil.

275 Gas pipes shall be maintained in good repair and provided with valves or cocks placed both within and without the boiler-house, in proximity to the gasometer.

276 There shall be placed in each pipe-line from the gasometers two safety wire gauzes, having at least 784 apertures to 1 square inch, at each side of which there shall be valves for shutting off the supply of gas. All gauzes shall be cleaned periodically.

277 The conveyance of gas direct from any well to a boiler is prohibited, unless a suitable gas regulator is fixed on the pipe-line leading from the well to the boiler (As amended in New Zealand Gazette No 12 of February 19, 1925.)

278. After every stoppage, previous to turning on gas for steam production in a boiler-house, a fire shall be made in the fire-box to prevent the forming of an inflammable mixture of gas and air. The cock of the gas-pipe line shall be opened gradually

279 The spraying system only shall be permitted when oil is used for heating boilers

280. A boiler fuel-tank shall be erected at least 11 yards from the boiler-house. In the construction of such tank the following specification shall be observed: -

- (a) There shall be attached to the bottom of the tank a sludge-pipe, which may be opened for cleaning purposes
- (b) The tank shall be so arranged that the ground in the vicinity shall be kept free of oil, and that the sprayer will receive nothing but pure oil
- (c) The pipe through which the oil flows to the sprayer from the tank shall be kept at a suitable height above the bottom of the tank, and shall have its inlet in the interior of the tank protected with a wire gauze. Outside the tank, but in proximity to it this pipe shall be provided with a valve
- (d) The pipes which convey the oil and steam to the sprayer shall both be placed on the same side of the boiler. For regulating the flow of oil and steam such pipes shall be provided with valves which may be safely manipulated
- (e) The arrangements and connections of all oil-pipes shall permit them to be blown out with steam.
- (f) All pipes and fittings shall be tightly joined
- (g) All openings in the firebox and its door, with the exception of the door of the ashbox, shall be provided with gauze safety protectors containing at least 784 apertures per square inch.
- (h) Unless the wall of the boiler-house opposite the door of the firebox is made of fireproof material it shall be covered with sheet iron
- (i) For covering spilled or burning oil there shall be kept in the boiler-house, or in proximity thereto, an adequate supply of dry sand. (As amended in New Zealand Gazette No 12 of February 19, 1925.)

—Shutting-off of Water.—

281. In every well subterranean water shall be effectively shut off by means of casing of adequate strength in order to prevent it from penetrating into the gas or oil stratum. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

282. The shutting-off of the subterranean water shall be done in a manner approved by and to the satisfaction of the Inspector. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

283. The Inspector may at his discretion and by written notification order the well-operator to make a test for the purpose of ascertaining whether or not subterranean water has been effectively shut off, and the well-operator shall comply with such order and carry out the test in a manner satisfactory to the Inspector. The Inspector shall be present at the test, and shall, in writing, notify the well-operator of the result of the test. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

284. It shall be the duty of the owner or manager of every well, after water has been shut off, to notify the Inspector of the steps taken to effect the shut-off.

—Log of Well.—

285. It shall be the duty of every owner or operator of an oil-well to keep a careful and accurate log of the drilling of such well, which shall show the character and depth of the formations or strata passed through or encountered in such well, the thickness, depth, character of water, gas, or oil-bearing strata, the depths at which such strata are sealed off, and the methods adopted to effect the shut-off water, gas, or oil, as the case may be; also the lengths, kinds, and sizes of casing used in the well, and the methods of seating each separate casing string

The log shall be kept in such form as is approved by the Minister, and a copy of same shall be forwarded to the Under-Secretary for Mines at the end of every calendar month.

—Abandonment of a Well—

286 (a). The well-operator, when he purposes to abandon any well, and before removing the rig or other operating plant therefrom, shall send a written notice of his intention to the Inspector, and the work of plugging the whole or pulling the casing shall not proceed until the Inspector shall be present to see that the said plugging is done as prescribed by these regulations, except as hereinafter provided.

(b) In case the Inspector fails to be present within ten days from receipt of notice then the work may proceed, provided that two men who have had at least three years' experience in the plugging of wells are present and make statutory declarations in duplicate that the work was done in accordance with the provisions of these regulations. Such statutory declarations shall be filed with the Inspector, and put on record in his office.

(c) If the well was drilled prior to these regulations coming into operation, the well-operator shall send to the Inspector with the notice of abandonment a description, together with a plan and section, showing the position of the well.

(d) Every well upon abandonment shall be plugged and filled tightly as follows: The whole shall be filled with rock sediment, mud, clay, or other suitable material from the bottom of the well to a hard and firm stratum below the last string of casing set in above the producing oil or gas sands.

(e) In the firm, hard stratum three seasoned wood plugs of a diameter equal to the diameter of the hole, and each of a length of at least 3ft, shall be driven into place. Above the third plug 10ft of clay shall be placed and thoroughly tamped down so as to prevent the passage of oil, gas, or water.

(f) Immediately below the seat of each and every string of casing there shall be driven a seasoned wood plug as described, and all spaces between wood plugs shall be filled solidly and tightly with rock sediment, clay, sand, or other suitable material as the casing is withdrawn length by length. All plugs shall be driven in place with proper drilling tools.

(g) The locations of the plugs herein prescribed are designated with reference to the relative positions of the gas and oil sands, for the purpose of preventing the passage of water into the oil and gas sands; and if any well presents a variation in such relative positions of the said strata such additional wood plugs as the Inspector may deem necessary shall be driven into place by the well operator.

(h) When the work of plugging and filling from bottom to top shall have been completed the well manager shall make a report in duplicate to the Inspector, on forms to be furnished by the Inspector, showing the date of completion of the well, the names of and the depths to all productive oil or gas measures, the total depth of the well, and the location and kind of all plugs and filling used, and the method followed in placing the same

(i) If the Inspector was not present at the aforesaid plugging and filling operations, the report thereon shall also be certified to by two men who have had at least three years' experience in the plugging of wells. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

287 Upon the abandonment of any well the owner or manager thereof shall furnish to the Under-Secretary for Mines, upon a form to be supplied for the purpose, a complete log or record of the well and a full description of the plugging

Installation and Use of Electricity —

288 The installation and use of electric light or power plants in the proclaimed petroleum district shall be in conformity with the regulations for the Installation of Electricity under the Mining Act applicable to well operations. In addition to which the following regulations shall, unless written exemption is first given by the Inspector, also be observed, but should the first-named regulations conflict with them the following regulations shall supersede:—

- (a) All apparatus and conductors shall be of sufficient size and power for the work for which they may be required, so constructed, installed, protected, used, and maintained as to prevent danger as far as is reasonably practicable.

- (b) All conductors and contact areas shall be of ample current-carrying capacity, and all parts shall be so protected as to prevent open sparking
- (c) All signalling wires and signalling instruments shall be constructed, protected, and worked so that in the normal use thereof there shall be no risk of open sparking
- (d) Adequate appliances, suitably placed, shall be provided for cutting off all pressure from every part of the system as may be necessary to prevent danger
- (e) Adequate provision shall be made for cutting off all pressure automatically from the part or parts of the system affected in the event of a fault or leakage of current.
- (f) All insulating material shall be chosen with special regard to the circumstances of its proposed use. It shall be of adequate strength for its purpose, and, so far as is practicable, it shall be of such a character or so protected as fully to maintain its insulating properties when used in inflammable gas, high temperature, and excessive moisture
- (g) Adequate means shall be provided for immediately indicating any defect in the insulation of a system
- (h) The insulating material of each cable-end shall be efficiently sealed as to prevent diminution of its insulating properties, and when necessary to secure gas-tightness there shall be properly constructed bushes
- (i) Generators, rotary converters, accumulators, or other equipment for supplying the current shall not be erected within a distance of at least 150ft from any well, tank, or gasometer
- (j) Transformers may be erected within the limits of the preceding paragraph, but not inside the derrick or adjacent buildings
- (k) The voltage of supply for lighting purposes shall not exceed 110 volts
- (l) When oil-gas commences to rise from any well, or from the time of shutting off the water with hermetic casing, only electric filament lamps shall be

used in lighting the derricks and the adjacent buildings. Every electric lamp shall be enclosed in an airtight fitting with a substantial protecting iron basket, and the lamp-globe itself shall be hermetically sealed. Switches shall on no account be placed near to a lamp in the prohibited area.

- (m) No oil-lamp shall be permitted for the lighting of derricks, or buildings adjacent thereto, unless authorised in writing by the Inspector. Such lamps shall be in special weather-proof boxes, placed outside the derrick or building, and protected by a strong and tight-fitting glass. The burner of the lamp shall be so arranged that the light may be extinguished without opening the box.
- (n) The use of any electric hand safety-lamp shall not be permitted until the type of lamp has been approved by the Inspector.
- (o) The use of electric filament lamps connected to sockets with flexible conductors is prohibited. Arc lamps shall not be used within a distance of at least 150ft from any well, tank, or gasometer, and the point of light when using such lamps shall be at least 40ft high.
- (p) Within a radius of 150ft from any well, tank, or gasometer the conductors shall be covered with approved insulation, such as double cotton insulation or double cotton braiding impregnated with red lead, or with simple cotton braiding and asbestos covering. The use of rubber insulation is not permitted within the area hereinbefore specified.
- (q) If the switches and fuses are within 150ft of a well, switches of gastight construction shall be used, and fuses shall be enclosed in gastight boxes. The use of ordinary lead wire for fuses is prohibited.
- (r) Every fuse shall be enclosed in a properly constructed box, and shall be of such construction or so protected by a switch that it may be renewed without danger.
- (s) Joints in conductors shall be carefully made, soldered, and completely insulated and protected by water-proof tape. The jointing of wires by simple bending is not sufficient and is prohibited.

- (t) At the derricks and adjacent buildings all conductors shall be run in metal conduits, which shall be electrically continuous and effectively earthed.
- (u) All motors shall be constructed so that when any part is live all rubbing contacts (commutators and slip-rings) are so arranged or enclosed as to prevent open sparking.
- (v) The pressure shall be switched off the apparatus immediately any open sparking occurs, and during the whole time an examination or adjustment disclosing parts liable to open sparking is being made. The pressure shall not be switched on again until the apparatus has been examined and the defect (if any) has been remedied or the adjustment made.
- (w) Every portion of the electrical installation, including all structural parts and electric appliances and devices belonging to or connected therewith, shall be duly and efficiently maintained. The plant shall be examined at least every six months, and at each examination it shall be specially ascertained if the whole installation complies with the regulations for safety from fire. The examination shall be made by the Inspector, and the faults which are discovered shall be immediately rectified.
- (x) During stoppages of work all pressure shall be switched off and in the event of a dangerous blow-out from any well the lights at the derrick shall be immediately switched off.
- (y) All broken or damaged protecting glasses shall be immediately replaced by new ones, and the replacement of lamps shall only be done after the pressure has been switched off. Whenever possible, repairs shall be effected in daylight.
- (z) In installing new plant and effecting repairs and alterations none other than an authorised person, or a competent person acting under his immediate supervision, shall undertake any work where technical knowledge or experience is required to secure safety. (As amended in New Zealand Gazette No. 12 of February 19, 1925)

—General Regulations.—

289 (a). An accurate plan or plans drawn to the scale of 1 in to a chain, kept up to date not more than three months previously, showing the boundaries of the property, the position of all well operations, tanks, gasometers, machinery, buildings, refineries, pipe-lines, electrical transmission lines, installations, fences, and roads falling within the area covered by the plan or plans, together with, where more than one sheet is required for the above purpose, a general plan to a scale approved by the Inspector, showing all the boundaries of the property, the position of all wells, and as many of the other details specified for the one-chain plans as can be clearly shown. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

290. The owner, operator, or manager shall at all reasonable times produce such plan, sections, or journal, and permit the same to be copied by an Inspector, or by any person whom any Inspector authorises on that behalf, and also:—

- (a) Shall, whenever requested by an Inspector or other person so to do, accurately mark on such plan or section the progress of the well operations up to the time of such request, and shall allow such Inspector or person to examine and take a copy or tracing thereof; and also
- (b) Shall forward to the Inspector once in every three months a copy of tracing of such plan and section, showing the well operations up to one month previously marked accurately thereon

291. Every plan and section of well operations shall be signed and dated by the person who surveyed such operations, upon every occasion when additions are made to such plan or section.

292. Every journal of well operations shall be signed and dated by the well manager.

293. Drilling shall be discontinued during lightning, when all workmen shall leave the derrick and connected buildings.

294. During a dangerous outburst of gas or oil operations shall be restricted to bring the outburst under control. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

295. There shall be provided and maintained at all well operations a stretcher and ambulance box containing first-aid appliances for use in cases of accident. (As amended in New Zealand Gazette No. 12 of February 19, 1925.)

296. Every manager and supervisor shall be acquainted with the methods of first-aid to the injured.

297. If oil engines are used for pumping in wells they shall be subject to the regulations prescribed for steam boilers, so far as the same are applicable.

298. If electric or gas motors are used for pumping in wells the foregoing regulations for the working of motors and electric installations shall be observed.

299. No explosive shall be used in or about any well or well operations without written authority from the Inspector.

300. A printed copy of these regulations shall be posted on a building or board in some conspicuous place in connection with every well.

301. The owner of any well, and any manager and any person in charge of or giving orders or directions relating to the carrying on of well operations, who contravenes or does not comply with any of the foregoing regulations shall be guilty of an offence, and shall be severally liable to a penalty of £10 in respect of such offence, unless the offender proves that all reasonable means were taken by him to prevent such contravention or non-compliance.

301 (a). Every person other than as mentioned in the last preceding regulation, whether or not employed in or about any oil-well, who neglects or wilfully violates any of the special or additional rules established for such oil-well is liable for every such offence to a fine not exceeding £5, or, in default of payment, to be imprisoned for any period not exceeding one month.

ELEVENTH SCHEDULE.

[Form 117 (Reg. 202).

Under the Mining Act, 1908, and Amendments thereto.

APPLICATION FOR LICENSE TO BORE FOR PETROLEUM OR
OTHER MINERAL OILS OR NATURAL GAS.

To the Hon. Minister of Mines, Wellington, N.Z.

PURSUANT to Section 15 of the Mining Amendment Act of 1919, and regulations thereunder, I [Insert full name, occupation, and address] hereby apply on behalf of for a license to bore for [State whether petroleum or other mineral oils or natural gas] on the land described in the Schedule hereto and marked on the accompanying plan; and I undertake to carry on all operations under this license, if same be granted, strictly in accordance with the provisions of the Mining Act, 1908, and its Amendments, and the regulations made thereunder

Dated at this day of , 19

SCHEDULE.

Insert full description of land, giving area, boundaries, section and block numbers, and names of survey district and county wherein situated also state whether held under mineral prospecting warrant, mineral lease, or any other title Give full particulars

[Form 118 (Reg. 203).

Under the Mining Act, 1908, and Amendments thereto

LICENSE TO BORE FOR PETROLEUM OR OTHER MINERAL OILS
OR NATURAL GAS.

PURSUANT to the Mining Act, 1908, and its Amendments, I, the undersigned, , Minister of Mines for the Dominion of New Zealand, do hereby grant to this license to bore for petroleum or other mineral oils or natural gas upon the land specified in the Schedule hereto, and marked upon the plan numbered lodged in the office of the Department of Mines, Wellington subject to the following conditions:—

- (a) The term of this license shall be _____ years from the date hereof.
- (b) The boring operations under the license shall be carried out strictly in accordance with the Mining Act, 1908, and its Amendments, and all regulations thereunder shall be complied with.
- (c) If failure to comply in any respect with the aforesaid regulations is reported by the Inspector, this license shall be subject to summary cancellation.
- (d) This license shall carry no inherent right of renewal, but on the expiry of the period of _____ years a fresh license may be granted on application being made in that behalf

Dated at _____ this _____ day of _____, 19____
 _____, Minister of Mines

SCHEDULE

Insert full description of land giving area, boundaries, section, and block numbers, and names of survey district and county in which land is situated and also state whether held under mineral prospecting warrant mineral lease or any other title

Gazette No. 103 of December 15, 1921 - Regulation 37 was amended by increasing the survey fees payable under sub-clause 21 paragraphs (a) to (j) by 25 per cent of the amounts therein stated

STATUTORY PROVISIONS DEALING DIRECTLY AND SPECIALLY WITH OIL AND NOT MADE APPLIC- ABLE TO OIL BY ORDERS-IN-COUNCIL

THE MINING AMENDMENT ACT, 1911

Section 2, as has already been remarked, the Governor-General is empowered by Order-in-Council gazetted to declare that any of the provisions of the Mining Act, 1908, shall apply to prospecting and mining for and the storage of petroleum and other mineral oils and of

natural gas, and to define the district in which any such Order-in-Council shall take effect. It is also provided that compensation shall in no case be payable in respect of the value of any mineral oil or natural gas on or in any land taken under the provisions of the Mining Act, 1908, in respect of which the owners of the land have consented, after the passing of the Amendment Act which came into force on October 28, 1911, to the issue of a mineral prospecting warrant. The Governor-General is further empowered by Order-in-Council gazetted to make regulations for the efficient control of operations in connection with prospecting or mining for and the storage of mineral oils and natural gas, and for the prevention of unnecessary waste thereof. In consequence of Section 2 the definition of mineral in the Mining Act, 1908, was amended to exclude petroleum and other mineral oils.

Section 12 empowers the Governor-General on the application and at the cost of the applicant to take land under the Public Works Act, 1908, as for a public work within the meaning of that Act, where for the purpose of conveying oil and natural gas or other produce of an oil well or oil refinery to any place of storage or for shipment it is desirable to carry any pipe or other work on or over or under any private land. The Governor-General is also empowered to take any such land for accommodation works in connection with the oil well or refinery. It is further provided that all the provisions of the Public Works Act, 1908, shall apply for that purpose, but the effect of the proclamation taking the land shall be to vest the land in the applicant instead of in his Majesty.

THE MINING AMENDMENT ACT, 1914.

Section 31 -The provisions of this section are most important, and require that in every license or warrant issued after the passing of the Amending Act and authorising mining on Crown lands for petroleum or other mineral oil, the following condition or a condition to the like effect shall be inserted—namely:

“The Government of the Dominion of New Zealand, or his Majesty’s Imperial Government, or the agents or representatives of the said Governments shall at all times upon giving reasonable notice to the

licensee, or without prior notice in time of emergency or of war with the forces of the said Dominion or Imperial Governments by land or sea, have the right in priority of all other persons or companies, and notwithstanding any contracts that may have been made by the licensee and are then subsisting for the supply of oil fuel or other products of the said works, to purchase at current rates the whole or any portion of the output of the said works and mines. The Government of the Dominion of New Zealand shall, in time of war with the forces of the said Government or of his Majesty's Imperial Government by land or sea, have the right at any time, upon not less than twenty-four hours' notice, to take over from the licensee the whole working, management, and control of the licensee's mines, workings, refineries, plant, buildings, and appliances, and to operate and use the same in such manner and for such period as it deems necessary, subject to payment to the licensee of the value of the output of the same at current rates, deducting the ordinary costs of working, but allowing to the licensee reasonable payment for interest on the value of the plant, mines, buildings, and appliances during such period, and for depreciation, wear-and-tear, or damage thereto, except such as may arise from the acts of the King's enemies."

THE MINING AMENDMENT ACT, 1919.

Section 15.—Like the section mentioned in the preceding paragraph this section is also a very important one, and was evidently passed so as to give the Crown effective control over boring operations by or on behalf of the owners of lands, which together with the minerals, including petroleum, have been alienated by the Crown. In effect the section provides that it shall not be lawful for any person to prospect for or bore for petroleum or other mineral oils or natural gas, except pursuant to a license issued in that behalf pursuant to regulations made and gazetted under the provisions of the Mining Acts under the provisions of sub-section 3 of Section 2 of the Mining Amendment Act,

1911, as extended by Section 15 of the Mining Amendment Act, 1919. The regulations have already been made and gazetted, and they have already been referred to or repeated in this paper.

Section 16 (1) (b) provides that Part X of the Mining Act, 1908, relating to loans to companies and persons for the development of mining shall, with the necessary modifications, extend and apply so as to authorise the making of loans for, inter alia, the extraction, rectification, storage, and transport of oil derivable or derived from swamp or other lands.

THE MINING AMENDMENT ACT, 1920.

Section 15 enlarges Section 387 of the Mining Act, 1908, by empowering the Minister of Mines to apportion and apply as he thinks fit all moneys which may from time to time be appropriated by Parliament for the purpose of encouraging prospecting or mining for mineral oils and natural gas.

THE MINING AMENDMENT ACT, 1924

Section 2 empowers the Governor-General on request in writing of any local authority, or public body, or trustee, including the Public Trustee or the Native Trustee, in whom any estate or interest in land or the control of any land is vested for any particular purpose, to grant (as the authorised agent of such local authority, public body, or trustee) over any such land a license or licenses to prospect thereon for petroleum or for mineral oil or for any natural gas, and to also grant leases to mine on any such land for petroleum, mineral oil, or natural gas. The consent in writing of any lessee, licensee, or other persons having any registered interest in the land must be obtained as a condition precedent to the Governor-General exercising his powers. It is also provided that every lease or license shall be subject to such terms and conditions as the Governor-General may in any case impose. The rents and royalties derived from any such lease or license after deducting therefrom an amount equal to five per centum thereof in respect of expenses of administration shall be paid to the person or body in whom the land is vested, to be applied in the manner lawfully

provided with respect to the revenues derived from such land. Notwithstanding anything to the contrary in any Act or in any rule of law every local authority, or public body, or trustee in whom any land or the control of any land is vested as aforesaid shall have authority to make the request already referred to herein

CONDITIONS OF MINERAL PROSPECTING WARRANT

In a mineral prospecting warrant which was recently issued the following conditions were imposed —

The licensee shall at the expiration of three years, or such extended time as the Minister of Mines may agree on, after crude oil is first produced by the licensee from his wells, if so requested by the Minister, forthwith make adequate provision within the Dominion of New Zealand for treating, converting, and refining the crude oil produced by the licensee, either by the erection, maintenance, and continuous working in New Zealand during the term of this license of all such refineries and works as may be necessary for the purpose, or by having the crude oil treated, converted, and refined at other works of a like nature within the Dominion of New Zealand as are capable of properly treating, converting, and refining the same, but so that the licensee shall remain responsible under the terms of this license for the due control, provision, and supply of all fuel oil and the products therefrom which shall result from or be the product of the licensee's works, mines, or other operations; provided that no requisition shall be made in this behalf by the Minister of Mines unless and until the licensee is producing from his oil wells crude oil in such payable quantities as would, in the opinion of the Minister, justify the erection of such refinery or refineries; provided, however, that if the licensee is dissatisfied with such requisition the licensee shall give to the Minister notice in writing of his objection thereto within fourteen days from the date of the requisition, and the question whether such requisition should be enforced forthwith shall thereupon be referred to arbitration in accordance with the provisions of the Arbitration Act, 1908, or any statutory variation, modification, or enactment thereof for the time being in force; provided always that if the objection of the licensee is sustained the Minister of Mines shall nevertheless be at liberty

at any time or time thereafter to make a further requisition or requisitions for the same purpose, subject, however, on each occasion that a requisition is made to the right of the licensee to have the matter referred to arbitration in the manner hereinbefore provided.

The Government of the Dominion of New Zealand, or his Majesty's Imperial Government, or the agents or representatives of the said Governments shall at all times upon giving reasonable notice to the licensee, or without prior notice in time of emergency or of war with the forces of the said Dominion or Imperial Governments by land or sea, have the right in priority of all other persons or companies, and notwithstanding any contracts that may have been made by the licensee and are then subsisting for the supply of oil fuel or other products of the said works, to purchase at current rates the whole or any portion of the output of the said works and mines.

The Government of the Dominion of New Zealand shall, in time of war with the forces of the said Government or of his Majesty's Imperial Government by land or sea, have the right at any time, upon not less than twenty-four hours' notice, to take over from the licensee the whole working, management, and control of the licensee's mines, workings, refineries, plant, buildings, and appliances, and to operate and use the same in such manner and for such period as it deems necessary, subject to payment to the licensee of the value of the output of the same at current rates, deducting the ordinary costs of working, but allowing to the licensee reasonable payment for interest on the value of the plant, mines, buildings, and appliances during such period, and for depreciation, wear-and-tear, or damage thereto, except such as may arise from the acts of the King's enemies.

PROCEDURE IN OBTAINING RIGHTS.

Having outlined briefly the provisions of the law, the writer now proposes to indicate shortly the procedure to be followed by any person who may desire to take advantage of the law.

Where any person or company has good reason to believe that certain land is likely to contain petroleum, and such land is owned by the Crown, the first step to take is

to apply for the issue of an Order-in-Council in terms of Section 2 of the Mining Amendment Act, 1911. The applicant would require to forward a lithograph plan showing the locality, boundaries, and area of the land referred to, together with a statement as to the justification for issuing the Order-in-Council. In the event of such Order-in-Council being made and gazetted, the next step to take is to apply to be granted a mineral prospecting warrant. If the land is within a mining district the application should be addressed to the Registrar of the Warden's Court, and if outside a mining district to the Commissioner of Crown Lands. If, after obtaining a mineral prospecting warrant, such person or company desires to prospect the land an application should be made to be granted a license in terms of Section 15 of the Mining Amendment Act, 1919. In practice an applicant for a boring license under that section is required to pay a deposit of, or to find approved security for the sum of £1000 as security that the conditions of the license will be duly observed and given effect.

In conclusion the writer cannot contend that even now the existing law is at all satisfactory. By far the greater portion of the petroliferous bearing land in the Dominion was alienated by the Crown many years ago and much of that land has been closely subdivided in several portions of the Dominion. The land so alienated is held under many different tenures. In some cases the mineral rights have been reserved by the Crown, but in other cases that was not done. In addition there are Native lands and many kinds of endowments the titles to which include the minerals.

It will therefore be seen that in order to obtain the right to prospect for and win petroleum great difficulties and large expenditure has to be incurred in obtaining such rights, and it has been found occasionally impossible to induce the land owner to sign an agreement to lease the petroleum rights, except at a prohibitive cost.

SUGGESTED LEGISLATION

What is really required is to repeal all the provisions of the existing law and to pass a Bill dealing specially with petroleum. The ideal principle of dealing with rights of this kind would be for the Crown to reserve to itself the sole right to grant a license to prospect, or a lease to win

oil. Where the petroleum does not belong to the Crown the owners of the land would, of course, be entitled to be paid adequate compensation for any land which may be damaged or occupied by prospecting and boring, and also a reasonable rate of royalty as well as rental.

Provision could be made empowering the Governor-General to declare portions of the Dominion which are believed to be petroliferous lands to be oil districts. The owners and others who are interested in such lands could be given an opportunity of lodging well-grounded objections against the issue of such order, and for such objections to be inquired into and reported upon by some responsible person. The Governor-General could be empowered to decide whether or not the objections should be upheld either wholly or in part.

It must be distinctly understood that these views are put forward merely for the purpose of discussion, and that they must not be construed as representing the views of the Minister of Mines or of the Government
to.

SOME ESSENTIALS FOR SUCCESSFUL OIL DEVELOPMENT.

By FREDERICK G. CLAPP.*

Introduction.—In a country that is unprospected, or little prospected, the question is sometimes asked: "What is necessary in order to establish successful oil development?" Most persons in other trades and professions have little conception of the complexity of the oil business and of the difficulties that attend a search for oil and the subsequent development of the industry. This ignorance frequently causes a state of apathy, so that in most countries where oil has not yet been commercially produced little substantial encouragement is given corporations that are spending their money in prospecting. The present paper endeavours to elucidate some of the existing misconceptions. The discussion is not considered as being more than an elementary one, but the explanations made may be of some value even in a highly enlightened country like New Zealand.

Advance Review of the Essentials.—Certain expressions used herein will be first defined. In inserting the word successful in the title of the paper the writer has in mind the axiom that oil and mining companies are organised for profit, and that they must be given a fair business chance of becoming dividend payers, otherwise their existence is unwarranted. Under development is included every phase of an oil-producing business, from the preliminary geologic studies, acquisition of leases or drilling rights, sinking of test wells, actual discovery of oil and its delivery to the market at a suitable price to enable the financial success of the company concerned.

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The essentials of oil development include such conditions of geology, land titles and laws, markets, economics, public opinion, personnel, etc., as may be vital to the success or failure of the enterprise. An axiom of oil development, as of every legitimate business venture, is that it shall fill a need and render service in proportion to the profit assured and inversely to the risk taken.

A few essentials of successful oil development are the following —

- 1 Suitable fundamental geologic conditions
- 2 Suitable secondary geologic conditions.
- 3 Suitable conditions for acquisition of a large area of leases for development
- 4 Experienced advice
- 5 Adequate capital.
- 6 Competent management
- 7 Suitable laws and regulations
- 8 Adequate and profitable markets transportation facilities, and unrestricted trade conditions
- 9 A helpful government and community
- 10 Actuality of the oil

Possibly in this enlightened age a few persons may remain of the opinion that the only necessary condition on which to base oil development is to find a favourable geologic structure, to drill a well on it and allow the oil to flow, whereupon the fortunes of the promoters will be assured and the district brought from a condition of poverty to one of wealth. How far this is from the truth will be explained. Some persons will even declare that favourable geology is not essential since, in their opinion, "oil exists where you find it." Such an idea is an alarming symptom, and the most reckless speculator would be foolish to trust his funds to a promoter of such calibre. As a matter of fact, the correctness of the geology is one of the first essentials to a successful oil development.

Fundamental Geologic Conditions.—In this brief discussion the writer can barely touch on the subject of Oil Geology which is an extremely intricate branch of engineering. A fundamental assertion is that an oil-field can not be safely predicted on the basis of one or two geologic factors alone, but many criteria must be given careful consideration. Even after a consideration of existing condi-

tions an oil-field can not be safely predicted simply because a majority of the questions, or most of them, have been answered satisfactorily; but every individual criterion should be answered affirmatively (or at least a negative answer must not prevail) if oil is to be wisely predicted. If every question can be answered favourably, test wells may then be safely drilled. If some of the questions be answered favourably and the answer to others be unknown the venture may still constitute a "good gamble" in the mind of an oil man; but as a rule if all but two criteria are answered in the affirmative and these two be answered negatively, the prospects are favourable. In fact, I know of only one fundamental criterion—namely, presence or absence of oil seepages or surface indications, that may be answered in the negative, and a reasonable prospect remains (under certain circumstances) of finding oil in commercial quantity.

The principal fundamental criteria which should generally be applied in a search for an oil-field in an untested region are the following —

- 1 Do surface indications exist?
- 2 Is the age of the strata similar to that in existing oil-fields?
- 3 Does a possible source of origin exist? If this be not apparent, may it nevertheless be present?
- 4 Do porous beds exist in which oil may be held in commercial quantity?
- 5 If so, does sufficient cover exist above these beds to prevent oil from escaping to the surface and becoming lost?
- 6 Are the strata so little metamorphosed (altered by heat or pressure) that the oil has presumably not been driven off in the geologic past?
- 7 Does any local geologic structure exist suitable for concentrating oil in commercial quantity?

The seven questions enumerated are among the first questions asked by a geologist who is searching for oil in any untested district. Surface indications are not always necessary, as many producing fields in the United States show no surface indications as oil or gas seepages, mud volcanoes, bituminous occurrences, saline springs, etc.

This may be because the strata are too thick, unbroken, or impervious that no escape of oil or accompanying fluid can take place.

The source of the oil may sometimes not be provable; but the geologist must make sure that conditions do not prohibit the existence of such a source, as would be the case if the surface consisted entirely of non-extrusive igneous rocks, or if the strata were exclusively quartz sandstone from the surface to the underlying igneous or metamorphic basement.

With these exceptions, however, all conditions should be answered favourably if the district is to be considered favourable for oil. In other words, if the strata be of an age in which oil is elsewhere unknown, or if their character be such that no possible source of origin can exist, or if no porous reservoirs with overlying impervious cover rocks exist, or if the geologic structure be not suitable for the concentration of oil in quantity, if any of these defects exist an oil-field is not likely to underlie the locality. Thus it is important that all fundamental criteria except the question of seepages be answered affirmatively, or, at least, that the criteria be not answered in the negative. If the answer be negative the field should not, as a rule, be recommended for development.

Secondary Geologic Criteria.—Assuming, however, that a possible source of oil be known, that seepages exist, that the age of the strata is identical with that of certain known oil-fields, that definite porous sandstones or limestones underlie the region, that they are covered with a thick clay capping, that suitable conditions of non-metamorphism have been found, and that satisfactory geologic structure exists, a geologist may be nevertheless obliged to report adversely on account of any one of several factors that may be called secondary criteria. That is, in addition to the fundamental criteria he may, in his reconnaissance or detailed studies, have discovered some of the following circumstances:—

1. Faults or "breaks" may exist in the strata. These may or may not be unfavourable to oil occurrence.
2. The region may be subject to frequent or violent earthquakes. Some persons have supposed these to be unfavourable.

3. Favourable porous beds, though present, may lie at such great depth that the geologist must inquire whether they can be reached by drilling.
4. Although porous beds be present they may form the surface, so that most of the oil may have leaked away in the past.
5. The beds may stand on end, in which case the structures may be so strong, so superficial, or so open as to raise a question whether they permit present retention of oil.
6. "Sands," though present, may be of insufficient porosity to hold oil in quantity, or too fine-grained and dense to yield oil readily by flowing or pumping.
7. If oil be present gas may not accompany it; hence no natural means may exist to drive the oil into the wells from surrounding portions of a productive stratum
8. Oil may be present but unsuitable for commercial use in the available markets.
9. A source of origin, though present, may not be so related to porous beds that oil can have collected in them (as, for instance, where petroliferous shales exist in a superficial formation, but the porous beds lie thousands of feet beneath)
10. Volcanoes may abound in the vicinity, and the geologist must inquire whether they have favourably or adversely affected the presence of oil
11. Geologic structures, though existing, may not embrace any of the well-known types in which oil is likely to occur in quantity. The structures must be carefully studied to ascertain their bearing on oil occurrence
12. Where artesian waters exist they may in some cases have affected the situation adversely, but the presence of artesian waters is not always unfavourable.
13. Oil may have been removed in times past by human or natural agencies. If any reason exists to suspect such removal, the facts should be ascertained and the doubts verified or eliminated

This list of possibilities that may exist and need solution is not a complete one. The various factors are enumerated in order to show how careful a geologist must be; and even with most complete studies a possibility remains of the existence of some unknown indecipherable unfavourable condition that may prevent the occurrence or extraction of oil in commercial amount.

Extent of Territory.—Even if the geology be favourable, the path to success is by no means clear, for the operators must have sufficient land on which to operate safely. To persons unfamiliar with the oil business it may seem strange that a corporation searching for oil requires leases or development rights on many thousands or millions of acres. Some corporations have been misnamed monopolists on account of their large holdings. Thus I must explain that in general a few hundred acres are not sufficient to assure a reasonable hope of success, if a company is to profitably supply the market with commercial quantities of oil or its products. An oil industry is a hazardous business, and investors in such a venture are entitled to an unusual percentage of dividends in the event of success, and their success can only be hoped for through large holdings.

Since the oil business is a hazardous one, it is suicidal for any company to limit itself or to allow itself to be limited to a few hundred acres of land. In an untested country thousands or millions of acres are necessary to assure any hope of success, since much of the territory will undoubtedly be found barren, and constant prospecting over large areas is necessary to eliminate the unfavourable lands. A company must be allowed to acquire a large area during its explorations so that, if oil be found, operations can be continued for many years. In a few instances where profit has been derived from operations on a few acres or a few hundred acres, the position of the field has generally been known in advance of drilling.

In the vast majority of oil districts, however, even in the United States and Mexico, the definite existence of oil was not previously known, and a large percentage of the wells drilled in trying to find it were failures. Extensive oil rights are required in order to assure shareholders "a run for their money," and, if oil be found, to enable the

company to embrace all contingencies of its existence and produce sufficient oil to pay for prospecting, unproductive test wells, and allow a reasonable profit.

The Government of Western Australia was wise in allotting exploration areas of hundreds of thousands of square miles to individuals or companies, because the chances of oil there were so unfavourable or so little known that no company could be expected to enter the State to explore or operate with any less inducement. But the wisdom of the Westralian policy ceased with the granting of a large oil prospecting area, for the holdings of an individual company were to be reduced by law, after the finding of oil, to an area of only a few hundred acres, a regulation which would oblige any company to resort to subterfuge or "dummying" in order to retain a sufficient area for profitable development. If a company can find oil in such a geologically unfavourable country as Western Australia it should be entitled to the entire oil prospecting areas over which it holds exploration rights. No oil development is practicable in a country having laws that reduce the holdings of a successful prospector materially after he finds oil by drilling.

Necessity of Experienced Advice.—An oil venture is found to be largely a gamble even with suitable geologic conditions. Hence in order to reduce the risk as much as possible, a company which intends to drill should employ only geologists with experience in the examination and appraisal of prospective oil-fields. The advice of novices or of quacks who locate by means of divining rods or non-technical instruments or unsound devices, should not be followed. Where a large amount of money is at stake, as in deciding the first important question of whether a certain region or district should be prospected, only the advice of experienced geologists should be followed. In later stages, after the fundamental and secondary geologic criteria have been found favourable, the advice of younger oil geologists may often be followed. There are many young men now in the profession who are employed on details of the business, such as in making locations, deciding what type of drilling equipment must be used, where to shut off water, at what depth to bail and test a well for oil, etc. With so many experienced men available there is no advantage in obtaining inexperienced advice.

Naturally this brief discussion can not enter the province of oil geology and explain how a geologist must proceed in solving the various criteria enumerated. Such a treatise is found in many good text-books, hand-books, and volumes of technical papers prepared by members of the American Association of Petroleum Geologists, Society of Economic Geologists, Institution of Petroleum Technologists, American Institute of Mining and Metallurgical Engineers, Geological Society of America, and other professional societies. To these and other publications the student of oil geology is referred; but, in addition to carefully studying their contents, he should serve his years of apprenticeship on a geological survey in an oil-producing district, with a large oil-producing company, or with a practicing oil geologist.

Adequate Capital and Competent Management.—In no kind of business is it so important to have adequate capital available as in a search for oil. The geologic investigations, establishment of a "land department," securing of leases or drilling rights, the employment of experienced oil well drillers, the purchase and importation of the best drilling equipment, and the actual drilling of test wells constitute an expensive start. If oil be not found in the first well additional test wells must be drilled, assuming that they are warranted by the local conditions. If oil be found, then the field must be thoroughly drilled at consequent tremendous expense. Storage tanks and pipe lines must be constructed and arrangements made for refining the oil.

It is obvious that no individual or company should embark on the business without sufficient funds available in advance of drilling, and the knowledge that additional backing can be secured in the event of striking oil. It is equally obvious that the development must be in charge of experienced oil operators, backed by wealthy financiers, and under the advice of experienced technical men. With all its hazards, oil development is not properly a gambler's business, but must be properly conducted to offer reasonable hope of success.

Some Essentials of Oil Law and Regulations.—Assuming now that all geologic questions have been satisfactorily answered, that capable personnel be secured, that plenty of

acreage be available, that capital and management be satisfactory, the road is not yet clear for a company to prospect wisely for oil. In some countries the rights to oil under the land are in part in the hands of freehold owners and in part held by the Government or Crown. The matter as to freehold lands is clear and generally satisfactory, for a company needs only to visit the owner and to acquire drilling rights from him on a suitable royalty basis, allowing the owner to continue farming or grazing or other use of the land without hindrance.

On Government land the matter is not so clear. Some sovereign States contain lands which are favourable geologically, but which no sensible oil company will enter, for the reason that laws or regulations are such as to permit little hope of profit. Some States which own their sub-surface oil rights offer from 1000 to 100,000 square miles to one individual or company for oil prospecting; yet the law provides that, if oil be developed therein, the area that may be retained and operated is less than the identical number of acres. In such cases no company can reasonably hope for profit on the oil prospecting area, unless an oil-field already be proven. Companies which have in the past made money on smaller acreages have either constituted exceptions to the rule or the sub-surface conditions and yield have previously been proven to such an extent that the hazard of drilling may have been justified.

The policy of substantially cutting down a grant after oil is discovered on it puts a penalty on the company, which spends its money in making a discovery. The laws should not require the discoverer to give up valuable rights after developing oil, but, instead, they should offer inducements for its discovery.

In the opinion of many students of the situation in oil-fields the world over a company should be given a long-term title to all land on a stated geologic structure after developing oil thereon, and should be free to continue prospecting on the balance of the oil prospecting area. This was an ideal for which many leading geologists and companies worked in the United States when the public domain was opened to oil development in 1920. Considering the great risks involved, even the areas allowed in the United States are too small for profitable operations in an undeveloped field. Certainly no Government situated outside

of an oil-producing country, or in which the presence of oil is as yet problematical, can afford to take an even less liberal view of the requirements, as has been done by States the world over.

Obviously the attitude of the Government and of the community in whose territory operations are to be undertaken must be favourable to the development; and a broad-minded public opinion is essential whereby private and public landholders are willing to meet the company half way, so that lands can be acquired on a basis that will be profitable to all concerned.

Necessity for Unrestricted Action of Economic Laws.—

In the oil business, as with farming or manufacturing, the natural laws of supply and demand should be allowed to operate freely. As is the case in farming and manufacturing, so in oil development; no price can be set, markets insisted on or restricted, methods of drilling or location of plant insisted on in advance by other persons than the operators, without danger of driving the business elsewhere. So many parts of the world yield oil with profit that strong companies generally refuse to operate except under the most favourable conditions.

In the oil business, as perhaps in no other, laws of supply and demand maintain full play. When over-production temporarily prevails nothing but lowering of prices will provide for the disposal of the excess output of oil products. Conversely, when a shortage prevails, only the companies that are directly concerned can fairly set a price at which the product can be purchased and sold by them. If a country be seemingly confronted by sufficient production to justify pipe lines, great storage tanks, refineries, and other expenditure, the men who are spending the money must of necessity determine to what extent they may safely expend money from the standpoint of financial conditions and future outlook.

Never in the oil business has the writer known an economic question to be solved by legislation or governmental regulation. Thus the economic essentials may be summarised by the statement that they must be kept free of legislation and regulation, enabling the operating com-

panies to work out their salvation on the basis of supply, demand, and competition, which throughout the world's history have constituted the best price stabilisers and distributing factors of any product in the markets that deserve attention. Even in the United States, that has successfully regulated the so-called trusts, the oil industry has not been interfered with by legislation affecting supply, markets, methods, or prices. The laws of supply and demand have there, as in all lines of business, been left free to shape the course of the industry, and this condition has made the United States commercially great from the standpoint of oil as of other commodities.

It is, of course, well for a Government to beware of monopolies. The writer holds no brief for the so-called trusts. He does not recommend that the oil business of any country be given over to a single company or that grants be made such as will stifle competition. Yet an oil producing company must have an area adequate for development for many years to come, and must be permitted to fight its way in the universal economic struggle, unhampered by laws or restrictions that might cause financial loss.

As an illustration, a refinery will be a necessity at some stage in the affairs of an oil-production business if a large amount of oil be encountered; and it is certain that a refinery will be built sooner or later in every country in which oil is found in quantity, for local refining will be cheaper than exporting and refining the crude oil. Yet no Government is wise in forcing a company to build a refinery or in obliging it to guarantee a refinery at any stage of its operations. The oil will soonest be developed and placed in the domestic market if the operating companies be unhampered and future steps be left to the discretion of the representatives of the investors themselves.

Dangers from Rapid Decline of Production.—The matter may be made apparent by explaining that a single great gusher in a new field would constitute no indication that commercial oil had been found. Gushers frequently decline rapidly, and it is necessary to allow a well to flow into tanks or a pipe line for months before even an approximate idea of its settled production can be obtained. It is unusual for a great gusher to hold its initial production for

a long period; and a well coming in at 1000 barrels daily is more likely to be flowing 100 barrels daily at the end of the first year than as much as 500 barrels at that time.

The initial well constitutes no indication as to the size of an oil-field. One well only tests a single spot in the earth, and in some fields no wells besides the first one have been found. It is necessary to drill many wells for the purpose of outlining the field before an idea of its size and volume can be obtained; then the officials of the company may be competent to decide whether to build a refinery, but other persons certainly are not competent to do so. If a decision be made too early the venture may fail. The incident of a company building a refinery at New Plymouth, New Zealand, many years ago before sufficient oil had been developed is sometimes mentioned to illustrate this truism. While the writer has not investigated the authentic history of the New Plymouth refinery, the analogy seems a perfect one.

Adequate and Profitable Markets, Transportation Facilities, etc.—It is, of course, evident that suitable markets must exist somewhere within the radius over which oil can be profitably retailed. If an adequate market does not exist in the country of origin of the oil, an unrestricted right should exist to export it. If the oil be of refining grade the company must be permitted to export it to a place where it can be refined until the company itself finds that economic conditions warrant the construction of a local refinery. If the business is to succeed conditions of tariff, transportation etc., must enable getting the crude or refined oil to the particular markets at which it can be sold for a profit. If these conditions be not suitable the business may fail, and the community as well as the shareholders will be losers thereby.

Attitude of Governments and Communities.—Since oil development is a hazardous business, it needs the encouragement of all persons. Governments, and organisations that come in contact with it. In short, it needs active assistance if it is to take its place as an asset to any community. Tacit friendship is not enough. If capital is to enter and be useful in a country's development legislation must be suitable for encouraging the growth of any infant industry.

In order to encourage oil prospecting a Government may wisely relieve machinery and equipment from import or other duties, as is done by some countries. Export duties may be subsequently enacted to protect the growing industry from aggression by outside monopolies. It is expected that a company entering any country to develop oil, thereby spending hundreds of thousands of pounds (as is imperative to assure success) will be protected in its efforts. A Government should use every effort to encourage, protect the rights, and facilitate the financial success of any company endeavouring to develop a country's resources, for thereupon depends the future prosperity of the country. The United States largely owes the greatness of its oil business to broad national policies, which have refrained from limiting or hampering the entrance of domestic or foreign capital.

In asking a State or a community for an encouraging attitude a company does not wish charity, but it is willing to take the legitimate risk involved in oil prospecting. The company may reasonably ask, however, that if profits be made, they will not be taxed at a prohibitive rate or legislated into oblivion. In asking for the co-operation of farmers in a section where it is planning to operate, a company does not want to be given any land or to buy land. All it wants is to lease the drilling rights for a sufficient number of years on a small royalty basis; then if the property be found unproductive after drilling the rights are returned. If the land be productive the land owner will share in the profit, and his royalty profit will probably equal the net profit of the company, handicapped as it is by the expense of drilling the productive wells and the failures.

Actualities.—It may be sometimes necessary to theorise, but the road is long and dangerous between venture and success. On March 5, 1925, a misleading article appeared in the *Lyttelton Times* entitled "Supplies for Centuries," the writer of which quotes Dr W. F. Schaphorst in a report prepared for the journal of the American Chemical Society. The article stated that "those who have made a study of the matter declare that the supply of oil is ample for hundreds of years." Nothing could be further from the truth. The fact is that studies by governmental and private geologists have shown that the oil-fields of the

United States may even now be approximately 50 per cent. exhausted, that few remaining fields remain to be discovered in that country, and that the consumption of oil is mounting rapidly year by year, so much so that it is anticipated the production of oil in the United States will largely cease within a few decades. When that time comes Venezuela, Russia, and other countries may take the place of the United States in supplying the oil needed for the industries of the world. As the fields of Pennsylvania ascended and declined so it will be with those of all productive nations, and Venezuela, Russia, and the rest will eventually decline as oil producers. If oil be found in New Zealand the same will be true there.

Petroleum supplies have been catalogued by students of the problem, and it has been found that a few decades will have removed the greater part of the extractable oil, after which some other fuel or power must be discovered or oil produced synthetically. The officials of large oil companies are not misguided fools; they have a definite plan of campaign, and the fields (even with the vast discrepancies between over and under-production) are, where the companies are unhampered, developed according to some system. The large companies wish to stabilise production and selling prices throughout the world, and they are to some extent succeeding. Any meddling by Governments only makes this problem more difficult, and results in greater variation of prices from month to month and year to year, according as world production is at the particular time over or under the existing and predicted consumption.

The writer is divulging no secret when he states that far-sighted companies would not drill for oil in New Zealand unless a reasonable chance of success existed. The operators have doubtless been advised in advance of drilling that conditions are sufficiently favourable to justify the speculation. Presumably their geologists have told them that potential favourable conditions somewhere exist. Nevertheless no geologist can look into the ground and see whether oil actually lies there. The most that can be done is to make predictions on the basis of existing conditions, some of which have been enumerated in this paper. The drilling of any well may result in failure, for failures occur even in great oil-fields. In fact, in the vicinity of

oil-fields the percentage of failures is generally large. The risk of not finding oil constitutes a real danger in any country that is being prospected.

Even if oil be present it may remain undeveloped owing to difficulties in drilling, of which there are too many to mention here. An additional danger is that some well-meaning but misguided Government will inaugurate policies, laws, or regulations which will seriously interfere with the development of oil in quantity, will insist on transportation, refining, or marketing conditions prohibitive to success, will overtax the product, or by some other means will cause the failure of the enterprise. The partial withdrawal of oil companies from Mexico was not due entirely to failure of the fields (although most great pools did turn into salt water producers and only about three oil companies have made money in Mexico), but the Mexican Government had so hampered the oil industry that business could not be conducted with profit. The fact that the oil-fields of Colombia have not been developed is partly due to unwise oil land legislation. British New Guinea remains undeveloped, not entirely because it is not a 'white man's country,' but largely because the laws do not permit a permanent acquisition of sufficient acreage on which to operate with any expectation of profit, perhaps partly because the Commonwealth's investment in a certain large monopoly has wedded the Australian Government to corporate policies which do not favour oil development.

Conclusion.—In the early days of oil development in any country it is habitual for the inhabitants to fear results, to suppose that the oil may injure the land, that the owners will be hampered if they desire to sell, or to fear some calamity which they are unable to define. As the development becomes an actuality, farmers and others generally reverse their attitude, finding their interests helped rather than hindered by the new industry. Trade conditions become better, lands increase in value, and their sale becomes easier. As fast as individuals come to receive royalties on oil they find themselves miniature oil magnates; thus fears vanish, and the closing stages of the business witness a complete harmony between owners, operators, and consumers, which is doubtless the end to be achieved in any community.

Such being the case, it is wise for an enlightened community like New Zealand to give every encouragement—personal, commercial, and legislative—that may permit early success to the companies operating. Thus the difficulties to be surmounted by the industry may be minimised and a new prosperity reach the Dominion, provided that oil be present in the fields in commercial quantities, and that the other essentials for successful development remain unhampered

SHORT ACCOUNT OF THE SEARCH FOR PETROLEUM IN EGYPT.

By H. T. FERRAR.

To those who are now endeavouring to develop the petroleum resources of New Zealand, a short account of the search for petroleum in Egypt should be of interest.

Seepages of petroleum from the rocks near the mouth of the Gulf of Suez were known in Roman times. A range of hills on the west or Egyptian side of the gulf, near the place where seepages of oil occur, was named *Mont Petroleus* by the Romans, and its present name, *Gebel Zeit* (Mount Oil), may date back to the time of the Arab invasion of Egypt, 640 A.D.

Apparently no attempts were made to obtain petroleum from these seepages until 1881, when the Egyptian Government arranged to purchase boring plant to test the field. Two serious attempts to obtain oil in quantity ended in failure, and the field was neglected until 1896, after the Government had expended more than £100,000 without result.

As Egypt prospered under British guidance, demands for permission to prospect for oil or to search for minerals of economic value became more frequent, and the need for a geological survey of the country was felt. In 1896 such a survey was initiated by H. G. Lyons, a retired captain of The Royal Engineers, who had patrolled the Egyptian deserts during military operations against the Mahdi and his followers. During this year, and again in 1898, officers of the newly-formed survey, after inspecting the *Gebel Zeit* area, came to the conclusion that the supply of oil that might be obtained would not be sufficient to repay working. This unfavourable report allowed the geological exploration of the country from an economic point of view to be undertaken systematically.

During the next ten years Captain Lyons appointed in succession as vacancies occurred a number of geologists to undertake this work. From among these appointees, T.

Barron, H. L. Beadnell, W. F. Hume, J. Ball, H. T. Ferrar and P. C. A. Stewart may be mentioned as taking part in mapping the Western Oases, portions of Sinai Peninsula, and large areas of the Egyptian deserts. Maps and reports dealing with the mineral resources of the areas examined were published as each piece of work was completed.

In 1906 companies began to be promoted for the purpose of prospecting for oil in various localities. In January, 1908, boring was renewed in the Gebel Zeit area at a place called Jemsa. By March the following year a bore was drilled-in successfully to oil, and by 1914 twenty-one wells had been bored in the Zeit-Jemsa area, of which seven produced flows of oil.

In 1917, owing to the demand for and the price of petroleum, a special credit for petroleum research was provided by the Egyptian Government. The pioneer work of the earlier geologists allowed the newly-appointed geologists, O. H. Little, T. G. Madgwick, F. W. Moon, and Hassan Sadiq, to concentrate on possible oil-bearing areas, and reports on these were published in quick succession during 1920, 1921, and 1922. About this time certain areas were defined as Government reserves, for the purpose of carrying out investigatory boring and perhaps obtaining supplies of oil. This work is still being prosecuted.

The general policy of the Egyptian Government has been an endeavour to encourage and foster the search for petroleum in its own territory, for the deserts are all Crown lands and not privately held, as are possible oil-bearing areas in New Zealand. Licenses to prospect comparatively large areas were issued at nominal cost. These licenses carried rights to take out mining leases over smaller selected areas, and both automatically lapsed if certain conditions as to exploratory or mining work were not carried out. By this means room for a number of operating companies was ensured, and companies already in the field were prevented from "squatting" upon large or promising areas to the exclusion of other companies. In granting the various permits the licensing authority interpreted the regulations in a liberal spirit and encouraged the search in other ways. This policy is being maintained.

Research has shown that the principal oil-bearing horizon is near the top of a series of sediments of Cretaceous age, where the Nubian sandstone merges into clays and fossiliferous limestones. Petroleum also occurs at higher horizons,

namely in Middle Eocene limestones and Lower Miocene sediments. The Nubian sandstone, more than 1000ft thick, is conglomeratic at its base, where it rests unconformably upon an ancient sedimentary series. In its upper beds are phosphatic limestones, prepared portions of which have been shipped to New Zealand for agricultural purposes. These upper beds may have attained a thickness of 1000ft. The calcareous Eocene strata are 2000ft or more thick; and Miocene beds, which include a vast series of calcareous deposits with gypsum and salt, in places may have attained a thickness of at least 3000ft. A succession of raised beaches completes the Tertiary series. Secular elevation and depression, faulting and folding, have caused dislodgments of greater or less extent in these Tertiary beds. Dome structures exist in places, but these are often dislocated by faults and are no sure indication of reservoirs of oil.

The sites of the earlier boring operations were chosen mainly on account of the presence of petroleum "shows," and apparently irrespective of rock structures likely to be favourable to the accumulation of oil. Prospecting operations were not influenced by the anticlinal theory of oil-accumulation until 1910, although as early as 1855 T. B. Oldham had drawn attention to the relation between anticlines and oil occurrences in the East Indian oil-field, and although in 1885 I. C. White had applied the theory to locate oil and gas fields in the United States of America. Structures favourable to the accumulation of oil are now sought by every prospector engaged in the search for petroleum and by every geologist engaged in field-work in unmapped country.

Well-known oil experts visited the Egyptian oil-field region from time to time, but seemed to find it difficult to interpret underground structures by means of the surface geology. Gaysoon Island was supposed to present favourable anticlinal conditions, but the borings made in this locality were "dry" holes as far as oil was concerned, and the results obtained near the Jemsa seepages could not be interpreted in terms of simple anticlinal structure. However, farther to the south, at the Hurghada sites selected for prospecting bores were determined in accordance with the "lie" of surface outcrops. Here, in 1911, W. F. Hume noted the occurrence of "oil-rock;" F. Wanner reported upon the area in January, 1913, and the first bore was commenced in July, 1913. In October, 1914, Hurghada No. 1 prospecting well reached a depth of 1670ft and produced oil from Upper Cretaceous sandy shales at an estimated rate of 1500 tons daily.

Boring operations were being carried out by experienced Canadian drillers during the time the writer was stationed in the oil-field region, but subsequently European drillers and drills were employed. In 1921 petroleum mining in Egypt employed 1480 Egyptians and 127 foreigners. At the beginning of 1922 the area held under petroleum prospecting licenses was 250 square miles, and five square miles were held under petroleum mining leases.

The following table shows the amount of drilling done, the number of wells drilled, the number producing oil, and the quantities produced during the 14 years up to 1921, from all borings in Egyptian territory.—

Year	Feet Drilled	New Wells Drilled and Drilling	Wells Producing	PRODUCTION (METRIC TONS)		
				Jemsa	Hurghada	Abu Durba
1908	1,415	2				
1909	3,547	6				
1910	18,506	19	4			
1911	16,847	24	5	2,793		
1912	9,506	21	5	27,962		
1913	9,059	14	6	12,786		
1914	9,271	18	9	88,491	11,189	
1915	11,319	17	8	13,144	16,910	
1916	8,775	11	12	10,895	46,848	
1917	8,317	15	14	6,875	129,970	
1918	10,714	12	19	5,017	276,868	
1919	6,754	14	21	4,231	227,686	
1920	12,916	12	25	2,730	145,220	
1921	22,657	26	31	4,209	178,284	175

SECTIONS OF COAL-MEASURES, KAITANGATA COALFIELD.

N.Z. GEOLOGICAL SURVEY.

By M. ONGLEY.

Coal was worked on the sea-shore at Coal Point, three miles south-east of Kaitangata, in 1858, and a small coal-mine was opened at Kaitangata in 1864. After 1876, when railway communication with Dunedin was established, the Kaitangata mines were worked on a larger scale. The sections here described are intended to show the general nature of the coal-measures in the Kaitangata-Milton district.

The oldest rocks of the south-eastern part of Otago are schists, supposed to be of early Palæozoic age. They are followed by moderately fine-grained sedimentary rocks, generally of bluish-grey colour, which may appropriately be termed greywackes. These greywackes are of pre-Permian age, but whether they are conformable or unconformable to the schists is not at present known. They are well exposed near Balclutha and in the hilly country between Milton and the sea.

After the deposition of the greywackes the region went through many vicissitudes, some of which are known, but need not be mentioned here. At last, late in the Cretaceous period, thick gravel beds, formed mainly of greywacke and schist pebbles, together with thin, finer-grained beds and numerous layers of vegetable matter, were deposited on the much-eroded, nearly level land surface of what is now the Kaitangata district. Other beds, later lost through erosion, may have followed. As time went on the gravels became conglomerates and the vegetable layers coal-seams, forming what may be called the Kaitangata coal-measures. A period of elevation, accompanied by tilting or folding and probably by faulting, came soon after. The elevated parts of the Kaitangata coal-measures were naturally more or less worn away, but in due course of time a series of conglomerates, sandstones, and shales containing several thick layers

of plant remains (now coal-seams) were deposited on the land surface. These beds form the Taratu coal-measures. Depression of the land was going on at this time, for a layer of sandstone in the upper part of this series contains marine fossils of early Tertiary age. Further, other marine beds, now removed by erosion, were deposited above the fossiliferous sandstone. In places the Taratu coal-measures lie unconformably (in the strict sense of that term) on the Kaitangata coal-measures, in places "disconformably," that is, without marked departure from parallelism.

Since the Eocene, geological changes of various kinds have taken place in the south-east Otago region. These need not be fully described, but it is desirable to say that the two sets of coal-measures, in common with the underlying rocks, have been elevated, depressed, tilted, faulted, eroded, etc., and thus finally the present-day conditions indicated by the sections have been reached.

Section I illustrates the section seen on the coast line from the north bank of the Molyneux River near its mouth to Measly Beach, about eight miles to the north-east. The alluvium of the low, narrow strip between the Molyneux and the sea is underlain by the greywacke conglomerates and other beds of the Kaitangata coal-measures. In the low cliffs along the coast, here and there obscured by sandhills, or broken by the valleys of small streams, the conglomerates are seen dipping at first gently towards the north-west (the beds in the section should here appear almost flat) and then to the north of east. At half a mile to nearly a mile from the north bank of the Molyneux several coal seams are seen. The quartz conglomerates of the Taratu coal-measures next appear, here dipping conformably, or almost so, with the Kaitangata beds, and with the associated beds continue to the end of the section. North-east of Caird Creek there are several small coal-seams. At Coal Point, three miles from the beginning of the section, is a 4ft seam. Three-quarters of a mile north-east of Coal Point is a 15ft coal seam, followed by several smaller seams. From here to Measly Beach the strata, mainly conglomerates, are almost flat.

Section II begins near the south end of the Tokomairiro Plain, five miles south-west of Milton. Here a fault with a considerable downthrow to the west brings the Taratu conglomerates, dipping 20 degrees west to the level of the plain. The coal shown in the section is not exposed here, but is seen at Elliotvale, a mile to the south. East of the fault the Kaitangata or greywacke conglomerates appear, and continue

to Waronui, nearly four miles to the east. Throughout they seem to dip almost uniformly 20 degrees west, but at Howard Stream the dip is less. On Mount Misery a patch of quartz conglomerate unconformably overlies the greywacke conglomerate. Near Howard Stream fine conglomerate, sandstone, shale, and very thin coal-seams outcrop. At Waronui the greywacke conglomerate is intruded by a basalt neck. East of this the ground rises, and quartz conglomerate and sands containing a thick coal-seam outcrop. These beds are part of the Taratu coal-measures, and dip gently south-eastward. Thus at Waronui they are almost certainly separated from the underlying Kaitangata coal-measures by an angular unconformity, as shown in the section. The section line, which from the Tokomairiro Plain to Waronui trends a little south of east, here bends to the south-east, and a little over three miles onward reaches the sea-coast at the mouth of the Tokomairiro River, about five miles north-east of Measly Beach. The beds lie almost flat, and, as elsewhere, are mainly conglomerates composed of small pebbles and grains of quartz.

A SECTION OF THE COAL-MEASURES AND ASSOCIATED BEDS IN THE WESTERN PART OF HUNTLY COALFIELD, WAIKATO, AUCKLAND.

By J. HENDERSON, N.Z. Geological Survey.

The Huntly coal field, in the middle Waikato district, south of Auckland, is the most important in the North Island, and yields an excellent brown coal largely used for domestic and industrial purposes. In the eastern part of the coalfield, near the township of Huntly, the coal-measures dip gently northwest beneath the post-Tertiary deposits of the swampy lowlands of the Waikato River. In the western portion, seven miles west of Huntly, the coal and associated beds are better exposed and the sequence is far more complete. Coal was first mined in the neighbourhood of Huntly, and for many years all the coal was obtained from that locality, but now the principal collieries, namely Rotowaro, Pukemiro, Glen Afton, and Waipa, are in the western part of the coalfield. Some years ago the Mines Department

purchased an area of coal-bearing land (Waikokowai) adjacent to the first three above-mentioned collieries, but this has not yet been worked. The accompanying section shows the sequence of strata in the Glen Afton and Waikokowai areas as determined by boring and surface prospecting.

The coal-measures, which consist of grey and brownish-grey non-laminated, poorly-consolidated clays, or rather claystones, are locally known as "fireclays," and rest on a gently undulating surface truncating the basal Mesozoic strata. The clay between the coal and the unweathered Mesozoic "understone" usually ranges from 10ft to 16ft thick, but in places is 30ft. The coal-measures were laid down on weathered Mesozoic rocks, which in places grade upward into the "fireclays." In the part of the coalfield traversed by the section one workable seam is present which ranges up to 25ft, but is commonly from 10ft to 15ft thick. In some places the seam is thin or altogether absent, and in others it contains many dirt bands or is represented by carbonaceous shale, though close by thick, clean coal may occur. There is usually a few inches of "bone" coal or carbonaceous shale on the roof and floor of the seam. Grey and brownish-grey clays, from 80ft to 110ft thick, overlie the seam. In some bores streaks and lenses of coaly matter and in other sandy layers, occur. These clays are probably estuarine, and they grade upward into blue marine claystones containing concretionary bands and, in their upper part, many arenaceous and calcareous bands. They are overlain conformably by the massive sandy argillaceous limestone that forms the prominent escarpment at Glen Afton. The upper part of the limestone is eroded in this locality, but in other parts of the district it is from 200ft to 250ft thick. The bores in the Glen Afton and Waikokowai areas indicate that the underlying claystone ranges in thickness from 60ft to 120ft, but, owing to the difficulty of separating the limestone from the claystone, the variation in thickness is probably more apparent than real.

OHAI COAL FIELD, SOUTHLAND, NEW ZEALAND.

By G. S. LANGFORD AND J. T. MOSLEY

This field is situated in the Wairaki Downs, about five miles from Nightcaps, and is connected to the Nightcaps railway by the Ohai Railway Board's line. The approximate area held by the existing coal mining companies covers about four and a-half square miles.

Besides the Black Diamond mine, which is working an extraordinarily thick seam (too distant to show on the accompanying plan), the companies in active operation are the Black Lion, Mossbank, Wairaki, Linton, Birchwood, and Ohai. On the western side is the Morley Colliery, at present in the development stage. These mines are all situated in the Ohai Valley, and all the seams outcrop on the banks of the river. The seams of the Black Lion, Linton, and Ohai mines outcrop on the northern side of the river, and the Wairaki and Birchwood on the southern side. The present workings of the Mossbank Company are in the valley itself. Besides these there were three mines in the Orawea watershed, the Wairio, the old Mossbank (now closed down), and the New Brighton.

At Nightcaps is situated the old Nightcaps Colliery, which was recently closed down through exhaustion after a profitable life of over forty years. Professor Park's map of the Wairio-Ohai coal-field shows that it extends from Nightcaps to the old Mount Linton pit, bounded on the north and east by a porphyrite dyke and argillites, to the west by limestone, and to the south by the greywacke and argillites of the Longwood Range. The only definite knowledge we have of the extent of the field is derived from work done in the mines, from surface outcrops and boring. With the exception of the Morley property and the Ohai Valley the field has not been proved by boring. The three bores put down by the Morley Company are the most important in the district, as they are situated parallel to the dip, thereby proving a large area of coal.

No 1 was bored to a depth of 1100 feet, and at 797 feet showed 12 feet of coal, at 866 feet a 28½ft seam, and at 1032 feet a 9ft seam. No 2 bore, put down 35 chains to the north and at an elevation of 190 feet above No. 1,

*James Park, the Geology and Mineral Resources of Western Southland Bulletin No. 23 (new series), N.Z. Geol. Surv., 1921.

was bored 525 feet without reaching the coal. No 3 bore, at the same level as No 2 but 10 chains to the south of it, cut a 40ft seam at a depth of 597 feet, and a 11ft seam at 949 feet. The inference is that the 12ft and 12½ft seams cut in No 1 bore had become one seam, while the bottom seam had thickened towards the north both seams being faulted between Nos 2 and 3 bore-holes. Professor Park reported that the field is traversed by a major fault following the course of the Ohai, and by many minor faults, running more or less at right angles to the Ohai Valley.

The Mount Linton Company found the dip section of coal with two bore holes before commencing opening out, and are now putting down a series of bores to prove their territory.

Owing to the lack of prospecting or a detailed geological survey, it is impossible to correlate the seams with any degree of certainty. The three seams recognised by Professor Park are the Rosin seam, the Main seam, and the seven foot seam. The Rosin seam, which ranges from 6 to 12 feet in thickness, crops out on both sides of the Ohai Valley. The Main seam ranges from 25 to 40 feet in thickness on the northern side of the valley and from 20 to 30 feet on the southern side. Can it be proved that the 40ft seam found in No 2 Morley bore-hole is the same as Linton dip seam?

The seven foot seam crops out on the bank of the Ohai River, almost directly below trig U, and on the southern side of the valley it has been proved by boring to lie 25 feet below the floor of the Main seam in Waitaki No 2 mine. According to the bore-holes put down by Mr W. A. Rodgers in the Ohai Valley, it appears to extend to the west although becoming thinner. This is not surprising, as the Main seam where it has been worked under the flat, also thins out. Again the seven foot seam was picked up in driving through the fault in the Main seam at Birchwood Colliery. It would be interesting to know whether this is the bottom seam intersection in the Morley bores.

The field is much disturbed by faulting. A large fault, running roughly north and south, apparently hading to the west in the Linton property, proved to be a reversed fault, throwing the seam about 30 feet up to the west. Another fault, not yet properly proved, but to all appearances a downthrow, runs approximately east

and west and hades to the north. This fault apparently traverses the Ohai Company's property. It has a hade of 45 degrees.

Between Wairaki and Mossbank mines there is evidently another fault, or extensive bending, for where the Wairaki dip is nearly due south the Mossbank dip is to the south of east. The eastern boundary of Wairaki No. 2 is apparently a downthrow fault, running north-east by south-west, and hading to the south-east, while in No. 1 workings, approaching this fault, there is a series of step and trough faults running parallel to the strike, at the same time causing the coal to rise towards the big fault. In the Birchwood Colliery a fault running east and west and hading to the south cuts off the Main seam. It would be interesting to know whether this is a normal or reversed fault, since on driving through it a 7ft seam was struck, whereas the Main seam was 30ft thick.

The dip of the seams varies. At Mossbank mine it is slightly to the south of east; at Wairaki the dip was at first nearly due south, and then gradually came round to south-west; at Birchwood the dip is south, as it also is in the Morley lease. The Mount Linton coal dips to the south-west, as also does the Ohai seam.

The presence of the faults and the frequent change in dip are great hindrances to the systematic working of the mines. Other disabilities are the occurrence of stone backs and patches of muddy coal. The stone backs follow the cleat of the coal, and range from a mere parting to a foot or more in thickness. Another form of impurity consists of a network of foreign matter throughout the coal, which may be up to two feet or more in thickness, usually thickest at the floor of the seam. In many places the coal is coated with a whitish clay, and where this happens it is of an inferior quality, containing a very high proportion of ash. In one part of the field the whole of the Rosin seam has been burned out. The fire, in some places, extended into the Main seam, and where this happened the coal has been completely destroyed.

In all the burned area the residual ashes rest directly on the coal now being worked, this necessitating special precautions while the pillars are being extracted. The general system of work on the field is bord and pillar, on the panel system, the first workings being from 12 to 16 feet wide by eight feet high. The coal is very strong, requiring little timber in the bords. When thus opened

out, the pillars are split and the tops shot down. The great thickness of the coal makes the clean extraction of the pillars impossible, and where there is a strong roof grinding and crushing of the stumps is liable to cause gas fires. Some of the seams give off a little fire-damp, and the mines worked with safety-lamps and permitted explosives are the Linton, Ohai, Birchwood, and Wairaki No. 1.

All the companies have to haul their coal from the Ohai Valley up to the level of the railway.

The Ohai coal is a high-grade brown coal suitable for household and steam purposes. Its great disadvantage in common with all brown coals, is its rapid deterioration on exposure to the weather. The following are the analyses as given by Professor Park in Bulletin No. 23 of the New Zealand Geological Survey, 1921:—

	Dossbank No. 1	Wairaki	Clapps Birchwood Seam	Linton Main Seam.	Linton Dip Seam
Fixed Carbon	46.90	44.10	45.60	45.6	47.4
Volatile Hydrocarbon	32.00	36.70	36.10	36.7	36.3
Water	17.70	15.80	16.90	15.5	13.5
Ash	2.80	5.40	1.40	4.2	3.0
	100.00	100.00	100.00	100.0	100.0
Sulphur	0.85	0.20	0.46	1.08	1.08

Owing to the short grain of the coal and the action of permitted explosives large quantities of are made, amounting usually to about 33 per cent gross output. This dross contains a fair percent good small coal, but the public are too sophisticated to use small coal, and hydro electric power is cutting out the smaller steam plants which were formerly consumers of dross. The consequence of this is that the general public is complaining about the cost of coal, while the companies have thousands of tons of good fuel going to waste. The heaps of small coal, moreover, form a menace to health and property, as it is only a matter of time till they will fire.

We should also say that, through their representatives the people of Southland have not acted in the best interests of the province, for from the waste coal of the Ohai district they could have derived cheap power for the population and industries of the province, which the ambitious hydro electric scheme now in progress to develop would have destroyed.

The map accompanying this paper shows the location of the various companies operating in the Ohai field.

THE ELECTRIFICATION OF THE DENNISTON COLLIERIES, NEW ZEALAND.

By JOHN CONNELL BROWN.

Westport Coal Company, Limited.

The Denniston Collieries are situated on the West Coast of the South Island, 13 miles from the port of Westport, at an altitude of 2000 feet. The original coal lease held by the Westport Coal Company, comprising 2479 acres, embraces a plateau considerably disturbed by faulting, with heavy and undulating grades and barren portions, which are due to the geological formation and subsequent disturbance, rendering economic mining somewhat difficult.

The scattered operations, extending over a large area, necessitated four steam plants in the following localities—namely:—

(1) Ironridge Mine, Kiwi Power Station, comprising two Roots boilers, each 100 horse-power 120lb steam pressure, and one 120 horse-power B. and W. boiler 120lb steam pressure. This plant furnished power to drive three air compressors and two Schiele ventilating fans. The underground haulage winches and pumps were worked by compressed air.

(2) Ironridge (main haulage units).—Situated at Wooden Bridge, consisted of two 86 horse-power B. and W. boilers, with engine and gearing complete.

(3) Cascade Power Station.—Four 120 horse-power B. and W. boilers 120lb steam pressure, generating steam for three air compressors, three haulage engines, and one 96in double inlet Sirocco fan. The pumps and underground units were driven by compressed air.

(4) At the break head four 120 horse-power B. and W. boilers 120lb steam pressure provided power for the main haulage engine, together with a number of steam units used at the storage bins, screening plant, workshops, etc., and a pump for hydraulic purposes.

Aggregating the power plants, the total horse-power available was 1400, and in view of further development of these Collicries and the apparent necessity for more steam plant the Company considered it advisable to instal a central station, and work future mining operations by electricity. To convert the various steam plants to one operated electrically was a matter of considerable importance, and a proposition that presented many difficulties, inasmuch that all the boilers at that time in operation were to be used under the new conditions, and as much more of the apparatus then in use as could be safely included in the new arrangements. It savoured very much of the resolution passed by a Council at Home, who, in sitting in solemn conclave, resolved that a new Town Hall be built; that it be built on the site of the present Town Hall; that all of the material in the old Town Hall be utilised in the building of the new Town Hall; that all the meetings of the Council be held in the old Town Hall, pending the erection of the new one.

I do not know what success the Council achieved, but I am pleased to say that the undertaking I am now dealing with was carried to a successful conclusion in the face of many difficulties.

Short deliveries occurred during the War period, hampering operations. Requisition No. 2 would arrive in some cases before No. 1. Notwithstanding the aforesaid, the output from the mines was maintained, and in no way were general mining operations impaired.

In considering the motive power to be used for producing the current necessary for the operation of the motors, etc., hydro-electricity took first place, and had there been an adequate supply of water available within a reasonable distance this method would have been adopted.

However, as this was not available, it was decided to use coal. Having decided this point, the next consideration was where to erect the power house. An adequate supply of water for condensing and circulating purposes was of paramount importance—i.e., if the best results from the engines were to be obtained. The Kiwi Power House site was admirably situated for an adequate water supply, but the difficulty of getting heavy machinery over mountainous country was manifest. Finally a site adjacent to

the Denniston township was chosen, and provision made for a water supply by building a dam close to the power house. This site, being situated within a reasonable distance from the workshops, screening plants, incline, etc., lends itself to more regular supervision by the management.

The power house has a floor space of 7616 square feet, the engine room is 67 feet x 42 feet, and the boiler room 98 feet x 49 feet. The building is built of wood and iron, the division between the engine room and the boiler house being of concrete. The engine room is lined the full height of the walls with asbestos sheeting. As soon as the building was completed provision was made to install No. 1 unit, but before this could be accomplished an 80 horse-power cylindrical dredge boiler was procured and installed in the boiler house. This enabled No. 1 generator to be installed, thereby cutting out a small steam unit in the Kiwi circuit, which allowed a B and W boiler to be removed and permanently installed at the power house, thus forming a nucleus of the Denniston electrical scheme. Unfortunately, although there were three boilers at Kiwi Station, only one was a B and W, the other two being Roots, and as it had been decided that only B and W boilers be installed at the new power house, for the sake of uniformity, it meant that none of the large units could be operated until more power was available. However, with the B and W completed and the dredge boiler, we were able to dry out the two generators, and later to run an additional fan at Kiwi by installing a 40 horse-power motor, thus displacing a steam unit used for driving the fan.

Boiler House.—This is arranged to accommodate 10 boilers, of which six at present are installed. A brick chimney stack, 105 feet high, is erected adjacent to the power house, having an overall base of 18 feet square and inside measurement of 10 feet 3 inches square. The flues are arranged to suit additional boilers if required. One was removed from Kiwi, three from Cascade, and two from the Brakehead Power Station. They were removed as conditions would permit. Careful calculations had to be made to carry out the general mining operations without seriously impairing the power available, pending the erection of any electrical units, haulage, or otherwise. I may mention that the whole group was thoroughly overhauled and put in

perfect order before being permanently installed, and, further, the group was arranged to enable automatic stokers to be used if deemed advisable. Adequate feed water heaters were installed, these being of local manufacture.

Power House Engine Room.—The engines were manufactured by Messrs Belliss and Morcam, Ltd., Birmingham. They are patent reciprocating self-lubricating two-crank compound engines mounted on combination bedplates, and are directly coupled to the generators. Two of these engines are 17 inches and 26 inches x 11-inch stroke, developing 430 b.h.p. running at a full load speed of 375 r.p.m., steam pressure 120lb, the third being 19 inches and 27 inches x 12-inch stroke, and develops 570 b.h.p. running at full speed load of 375 r.p.m. A surface condenser, supplied by the makers of the engines, is also installed, this being of sufficient capacity to deal with the steam from two engines, whilst provision has been made by the stop valves to exhaust into the atmosphere if found necessary. The double acting air pump supplied with the condenser is driven by a 10 horse-power motor manufactured by the British Westinghouse Company. It is of the slip ring type, 710 r.p.m., complete with switch, fuse, and starter.

Generators.—Three of these are installed, each of which generates an alternating current (3-phase) at a voltage of 3300—50 periods 375 r.p.m. Two of these machines are 400 k.v.a. British Westinghouse type, and the third one has a capacity of 500 k.v.a. when running on a full speed load of 375 r.p.m. This generator was manufactured by the Swedish General Electric Company. Connection is made between the generators and switchboard by means of 3-core lead-covered cables enclosed in earthenware conduit buried in the concrete floor of the engine room.

Exciters.—Two of these are provided to supply the necessary direct current for magnetising the field magnets of the alternators. They consist of British Westinghouse dynamos, direct coupled to the Belliss-Morcam high speed steam engines, both generating direct current at 115 volts pressure at a speed of 600 r.p.m. They are 20 k.w capacity, and were originally used for lighting purposes underground, and to enable them to be used as exciters for alternating

current generators field rheostats were procured, these being placed immediately below the switchboard platform, all the operating mechanism being controlled from the switchboard.

Main Switchboard.—This consists of nine wrought iron cubicles, which are mounted on a concrete platform, supported by railway irons, and raised 8 feet from the engine room floor level. They are reached by iron ladders placed at each end of the platform.

The total length of the switchboard is 25 feet 6 inches, including the bracket supporting the two 12-inch voltmeters, synchronoscope, and synchronising lamps. The height of the cubicle is 7 feet and the depth 2 feet 5 inches.

Access to the interior of the cubicles by unauthorised persons is prevented by having the doors fitted with locks of the "Yale" pattern.

All live parts of the board are contained in the locked-up cubicles, so that the outfit is practically fool-proof as far as danger from shocks is concerned.

As a further protection an india-rubber mat, the width of the platform, $\frac{3}{8}$ inch thick, and running the whole length of the platform, is provided.

Starting from the left hand side of the board the first apparatus we come across is the swinging bracket, on which is mounted two 12-inch illuminated voltmeters, synchronoscope, and synchronising lamps. This bracket is supported at the end of the switchboard.

"A" Excitation Panel.—This panel supports all the instruments for controlling the exciters used for supplying direct current for the field magnets of the alternators.

These are as follows:—Five ammeters, two voltmeters, operating handles for seven field switches, three combination hand wheels for use with the field rheostats mounted under the platform, safety fuses, two pilot lamps with fuses, and fuses in the field circuit. The operating portion of the switches are placed at the back of the panels, the switch handles only being in front.

The excitation panel is 3 feet 8 inches wide, all of the others being of a uniform width of 2 feet 4 inches.

“B” Generator Panel.—On the front of this panel is mounted three ammeter fuses, voltmeter plug, etc., switch circuit breaker handle, type “A” polyphase relay, type IV reverse and current relay synchronising plug. In the cubicle at the back is mounted three isolating switches, oil tank, and switch mechanism for the oil switch circuit breaker, current transformer, and shunt transformer.

“C” and “D” Panels are equipped in the same manner as “B” panel, the only difference being that as “D” panel has to deal with a heavier current suitable instruments are provided.

“E” Meter Panel.—Item for measuring the supply of current sent out from the station, as well as checking the frequency and power factor. On this panel is mounted an ammeter 0.5 amp. power factor meter, frequency meter, indicating wattmeter, integrating wattmeter, pilot lamp, fuses and switch, and handle for controlling knifed switch, and the gear mounted in the cubicle at the back of the panel consists of three isolating switches, potential transformers, and fuses, switch mechanism, and three Le Clanche cells, these in connection with the double pole switch and low reading ammeter are for testing the leakage of current.

“F” Feeder Panel.—On the front of this is mounted three ammeters, integrating wattmeter, oil switch circuit breaker, pilot lamp, fuses and switch, polyphase time limit relay.

In the cubicle at the back the following is mounted:—Three isolating switches, oil tank, and operating mechanism in connection with the oil switch circuit breaker, current transformers.

“G” “H” “J” Feeder Panels.—These are all equipped the same as cubicle “F,” the only difference being in the ammeter readings and the capacity of the switches, these being varied to suit the various watts carried.

Earthing Bar.—Mounted at the base of each cubicle a copper earthing strip is provided, and arrangements made so that they can be bolted together. This is constructed

so that the metal portions of the cubicles can be easily earthed. All instruments at the back of the panels in the cubicle are mounted on slate or marble bases.

It may be of interest to note here than panels "D" and "J" were left blank, while space was provided on panel "A" for installing the necessary instruments for use with a third alternator. The advisability of this being done was shown when it became necessary to increase the size of the generating plant, as no alteration was required in the layout of the switchboard or the position of the various panels.

The D.C. current for supplying the pilot lamps, mounted in front of the panels, is supplied by the generators supplying the exciting current for the alternators.

As the voltage of supply in the power house is 3300, and as voltages of 400 and 230 were required for lighting the power house and running motors contained therein and in the immediate vicinity, three 30 k.v.a. transformers were installed with a ratio of 3300/400/230, complete with a cubicle switchboard for the purpose of controlling the various circuits of lighting and motors installed. The units at present are a condenser pump motor, centrifugal pump motor used for circulating water from the dam through the condenser, and provision has also to be made for the supply of current necessary to operate the automatic stokers if deemed advisable to adopt these.

The transformers and switchboard cubicle are placed under the main switchboard platform.

Lighting Protection.—To provide for this an electrolytic lightning arrester, manufactured by the Westinghouse Company, has been installed at the power house, in addition to "Horn Gap" arresters and choke coils on each outgoing line. These lines are supplied at intervals with special line type "Horn Gap" arresters, complete with "Koppatt" resistors. This type of arrester is also provided at each borehole, where the armoured cables are jointed to the bare copper cables, to prevent as far as possible lightning getting down the boreholes and damaging the transformers placed in the sub-stations underground.

Arresters are also provided at each motor in the sub-stations where the haulage gears and large fans are placed.

In connection with these a large "Brazil" earthing resistance is provided and installed under the switchboard platform in the power house, to prevent abnormal rush of current from taking place to "earth" in the event of a lightning discharge taking place across the lines and the line current following it.

Wiring.—All station wiring is carried out with 2500 megohm V.I.R. wire. The leads from the switchboard are led through the wall in porcelain insulating entrance tubes and then secured to high tension insulators. Bare copper wires are used throughout the outside installation, except in one or two cases which will be specified later. The cables are carried on H.T. insulators, mounted on rata cross arms, provided with special galvanised brackets, the whole being supported on ironbark poles. These latter carry "danger notices," and where the lines cross public roads safety brackets are provided for the safety of the public.

Most of the holes for the reception of the poles had to be blasted out of solid rock.

The total length of H.T. lines to the respective units connected with the system is approximately 6 miles 11 chains. From the power house to the Brakehead is 55 chains.

The H.T. lines terminate at the sub-station, wherein there is installed the H.T. switch gear, similar to the distribution boards described in the power house, controlling three 100 k.v.a. single phase transformers, the voltage being 3300/400/230. There are also two cubicles controlling the supply lines to the various motors at the brakehead. The controlling apparatus in the sub-station is fool-proof. The building is constructed of non-inflammable material—namely, bricks and iron.

Ironridge Endless Rope Haulage Gear.—The H.T. lines from the power house to wooden bridge are 58 chains in length. The original haulage gear was actuated by a vertical steam engine, and steam supplied by two 86 horsepower B. and W. boilers at 120lb pressure. The gear is now being worked by a 3300 volt B.W. motor of 150 horsepower mounted on a combination bedplate, and fitted with

speed reduction gear of the double helical type, running in oil. The plant was supplied by the Power Plant Company. In this case the plant was running under steam on the Saturday up till 12 o'clock noon. The alterations were commenced at the time stated, and the engine was removed, together with pipe fittings, etc., and the whole of the electrical apparatus was installed and in operation on the following Tuesday morning. This motor has an oil-immersed controller and also an oil-immersed switch circuit breaker fitted on a pillar.

It is provided with a transformer operating an alternating current electro-magnetic brake. The apparatus is protected from lightning discharges by arrester and choke coils on each line. The H.T. lines traverse undulating country from wooden bridge to a 30-inch Sirocco fan, a distance of 36 chains, where a 15 horse-power motor, together with a 15 k.v.a. transformer are installed, the latter cutting down the voltage from 3300/400. This unit is used for ventilating purposes. From this point the H.T. lines are continued a distance of 30 chains to a borehole 120 feet in depth into the Ironbridge Mine. The underground transformer at the sub-station is connected with the surface by a 3-core armoured cable. The Kiwi ventilating fan is situated 26 chains from the borehole. The line terminates at this point, where a 50 k.v.a. transformer reduces from 3300/400 the voltage supplying current to a 40 horse-power B.W. 400-volt motor which drives a belt-driven Schiele fan. This motor is complete with auto-starter, enabling the unit to be started automatically. This is to assure the fan being set in motion in cases where the circuit breaker in the power house has operated. The H.T. lines continue from a point adjacent to the borehole, a distance of 91 chains, where they terminate at a 50 k.v.a. transformer situated adjacent to Deep Creek endless rope haulage, which is driven by a direct coupled 25 horse-power 400-volt A.S.E.A. motor controlled by an automatic switch and controller.

Haulage Gears: Cascade, Wareatea, and Coalbrookdale.—These three sets are practically similar, with the exception of the difference in the power of the motors. Cascade motor is of 150 horse-power, Wareatea 130 horse-power, and Coalbrookdale 60 horse-power. They are all

worked direct off the line at 3300 volts. They are situated a slight distance apart, and under the old regime required one man to operate each steam unit. Now one man works the whole three. The incoming lines are provided with lightning arresters and choke coils at the controller house. Each motor is provided with reversing controlling gear, etc., also transformer for operating the electric magnetic brake. They are all geared to double reduction gear and manufactured by the Power Plant Company. These three motors are situated in what we call the controller house. This looks very like one of the signal boxes seen at some of the larger railway stations. It consists of a ground floor and a first floor; the banks of resistance used in connection with the speed reducing of the motors are contained on the ground floor. The controllers for use in connection with these are located on the first floor, each resistance being placed immediately below the controller it has to be used with. The controllers are of a special type, oil immersed, with lever handles so arranged as to take up little space and enable the operator to work all the three with practically very little movement from the one position. All controllers supplied are arranged on this plan so that one man working a controller in one part will be quite "au fait" with the operation of any of the others.

The bell signalling system is operated by one 100-watt transformer, 230/15 volts, operating three different sounding bells. This system has given entire satisfaction, cutting out 50 Le Clanche cells and relays.

The total length of H.T. lines from the power house to this point is 2 miles 5 chains. The main haulage referred to handles the whole of the output from the Coalbrookdale Mines. Cascade and Wareatea haulages are fed by subsidiary haulages and winches underground.

The H.T. lines extend from the Coalbrookdale surface haulage units a distance of 21 chains, where a 50 k.v.a. transformer is installed to manipulate the operation of the underground units in Cascade Mine. These units are connected up by 3-core armoured cable

Cascade fan house is situated adjacent to the transformer mentioned. The fan is rope-driven by a 190 horsepower Swedish general electric motor working at line pressure I.E. 3300 volts.

This fan is a 96-inch Sirocco type, and was previously direct coupled to a Browett and Lindsay high speed engine. The fan had, of course, to be left in its original position and means taken to drive it electrically. It was eventually decided to operate it by a rope drive, and orders were sent for the necessary grooved pulley for the fan, together with a length of shafting, coupling, etc., and at the same time the motor was ordered with a grooved pulley arranged to take eight ropes. As an outer bearing was necessary for the length of shafting to be provided for carrying the grooved pulley driving the fan, the question arose as to the manner in which this bearing could be mounted to let the concrete set, as the fan could not be stopped for any length of time. This was rather a serious question. However, it was overcome by sending Home a template of part of the bed of the engine in which four holes were provided, and instructions were sent that a section should be made to this measurement to which the bearing was to be secured, so that when the engine was removed this piece could be put into position. As there was no concrete to set no delay was experienced in getting the fan into operation. I must mention that a full plan of the whole arrangements that were intended was sent home to the makers of the fan, and they carried out their part of the work in a highly satisfactory manner. As there was a creek alongside the fan house a motor house was built, 36 feet centres being allowed between motor and fan. A covered way was provided over the ropes and a guarded platform built connecting the motor house with the fan house.

As in the other cases, all necessary switches and control gear were provided.

The H.T. lines continue from the Cascade fan to Wareatea borehole, a distance of 57 chains, where a 3-core armoured cable connects these lines with the underground transformers at a depth of 122 feet. At right angles to the H.T. lines leading to Wareatea borehole, a distance of 14 chains from the above-mentioned lines, another borehole 170 feet in depth was put down, and the lines are connected with a 3-core armoured cable attached to one 15 k.v.a. transformer situated in a brick-built sub-station fitted with the necessary switch gear for pumping purposes. Close to the sub-station a 5 horse-power motor is installed for driving a direct coupled 3-inch centrifugal pump.

Another set of H.T. lines are connected to the Cascade fan lines, and continue over the surface for a distance of 46 chains to the Wareatea extended section, and coupled to a 50 k.v.a. transformer on the surface, which reduces the current from 3300/400. (The appended tracing shows the position of the H.T. lines on the surface.)

Underground Subsidiary Haulages: No. 8 Cascade.—

A 30 horse-power motor was installed, driven at 400 volts, and is attached to suitable reduction gear for driving an endless rope haulage. The armoured cable for this unit is connected to a 50 k.v.a. transformer at the Cascade fan. There is also a 20 horse-power motor driving a haulage winch in the section under review.

Wareatea Sub-station.—This contains two transformers, one 3300/400 and the other 3300/200, 400 volts being used for haulage purposes and the 200 volts transformer supplying the pumps. The sub-station is fitted with all the necessary switch gear controlling the respective distribution lines.

Wareatea No. 2 Haulage.—This is fitted with a 45 horse-power A.S.E.A. motor belt driven with all necessary controlling gear. I may mention that there are two endless rope haulage plants which are manipulated by clutch gear on motor operating the two endless haulage appliances. In the Wareatea and Wareatea extended sections there are three haulage winches, comprising two 20 horse-power A.S.E.A. and one 15 horse-power B.W. all slip-ring motors, with controller attached. The winches are direct driven, with motors fitted on one bedplate. A fairly large amount of water percolates through the comparatively shallow strata overlying the seam. This, together with the undulating ground, renders necessary a number of pumps. There are eight in use in these two sections, varying in size—three 15 horse-power motors each driving 5-inch centrifugal pumps, three $7\frac{1}{2}$ horse-power motors driving ram pumps, and a three horse-power and five horse-power motor each driving 3-inch centrifugal pumps. All are fitted with the necessary controlling gear.

In the Ironbridge Mine there is one 15 horse-power A.S.E.A. motor driving a haulage winch and one $7\frac{1}{2}$ horse-power motor, belt driven, connected to a 3-inch centrifugal pump. Notwithstanding, provision is made by adequate water drives to deal with very large quantities of water. The undulating grades previously mentioned compel the use of pumping appliances to deliver portion of the water into the drives.

To facilitate the general operations adequate telephonic communication is installed between each of the sub-stations, fans, haulages, and the power house

Screening Plant: Loading Appliances and Workshop.—

The whole of the appliances and plant are driven electrically, making a total horse-power of 227 $\frac{1}{2}$. Forty horse-power is used for workshops, including the carpenters' shop, the balance being required for the screens, picking belts, loading conveying belts, and discharging belts to and from the bins, slack elevator, tub creepers, winch, and pump. The latter requires special mention. The altitude of Denniston renders it impossible to get adequate water pressure without mechanical means, and to get pressure to work the bin doors by hydraulic rams a $7\frac{1}{2}$ B.W. motor geared to a three throw pump was installed. The motor is fitted with tappet switch and automatic starter, thereby maintaining a constant pressure in the accumulator cylinder.

The total horse-power installed at the collieries in motors is 1358. However, owing to intermittent running, at no time are units all working together. The total k.v.a. of the generating plant is 1300, and that of the transformers installed is 1123.

The Denniston and Burnett's Face townships are lighted from the power station, and workmen receive current for lighting at a reasonable rate.

It is interesting to note that the total number of boilers in use at the Denniston Collieries prior to the advent of electricity was 13, these including the respective power and all surface haulage plants were attended to by 21 men—i.e., when the mine was fully manned. Under the present system the number of men engaged at this work is 16, therefore the economic aspect is quite satisfactory. The coal

consumption has been reduced approximately 5500 tons per annum, and in view of the large quantities of water pumped and the additional underground subsidiary haulages put into operation since the installation was accomplished, this is clearly a saving of coal consumption much in excess of the aforesaid figures.

In conclusion, I wish to place on record my thanks and appreciation to Mr R C Jones, of Messrs Turnbull and Jones, engineers and contractors, for supplying much of the data required for this paper.

The firm referred to supplied and installed the electrical plant all of which was erected under the supervision of Mr R C Jones. The work throughout was carried out in a highly efficient manner.

I also wish to thank Mr J. Adams, the Company's electrician, for supplying a considerable amount of detailed data

PROTECTION OF UNDERGROUND ROADWAYS.

By E. S. WIGHT.

Lignite mines in particular, owing to the water contained in the coal, are mostly liable to a fretting of the pillars as the water is given off. This deterioration of the pillars on main haulage roads and airways is liable, as time goes on, to seriously weaken the pillars and cause accumulations of loose coal, which in turn may result in fires. To say the least, it causes much annoyance and expense in proper maintenance.

During the summer of 1923-1924, the long continuance of high temperature caused very serious fretting in one line of roadways, which were driven on true heading course in Pukemiro Colliery, causing the management to consider carefully what might be the most effective means of prevention.

Timbering was duly considered, but as there was not natural pressure of roof or side it was decided that guniting would be the least costly, most quickly done, and would be effective.

The writer does not propose to go deeply into the detail process of guniting, as it is already well known to mining engineers. Suffice it to say that the aggregate, consisting of three parts of dry sand to one of cement, is supplied to the gun. This is worked by an impeller to the rubber tube, through which it is driven by compressed air, at about 80lb pressure to the outlet nozzle, where it is met with a jet of water at a slightly higher pressure. The man in charge of the nozzle directs the mixture to the desired place.

It is absolutely essential that thoroughly dry sand be used. In the first trials at Pukemiro it was thought the sand was dry enough, but the result was a clogging of the hose, which takes a long time to dislodge

Pukemiro has been fortunate in being able to obtain supplies of dry sand from a local works, which, although rather fine, answers the purpose very well. It has not been obtainable in quantity sufficient to keep the gun in continuous work, consequently the men were engaged in preparing the roadways in off time

It is believed that Pukemiro is the first colliery in the Dominion to adopt guniting, and as the Mines Department are exhibiting photographs of the work done, the writer will give a few facts bearing on the work, hoping the same may be of interest to those who may contemplate the use of the cement gun

The cost of the plant complete, including air compressor, motor to drive same, and the gun was approximately £1000

A total length of 2600 yards of headings (sides and roof) has been gunited with a thickness of about $\frac{3}{8}$ inch, and only in a few odd places, where the surface of the coal was particularly bright and smooth, is the coal showing in a patch occasionally

A general idea of what might be done if kept constantly supplied with material, and the work prepared for guniting, may be instanced by the following figures obtained from one test, which was not an extraordinary one

	£	s	d
Sand (17 bags at 3s per bag of 4 cubic feet) ...	2	11	0
Cement (17 bags at 7s 1d per bag of 1 1-3 cubic feet)	6	0	5
Mixing and bagging (two men)	1	11	6
Guniting (three men at 19s)	2	17	0
	£12 19 11		

This amount of material covered 38 lineal yards of heading 9 feet by 6 feet first coat

The same amount of material covered 50 lineal yards of heading the same size with a second coat

The reason the material goes farther in the second coat is because a large portion of the first coating goes in filling up crevices between blocks of loose coal, which it is not found necessary to clear away

From one setting of the gun the aggregate has been applied a distance of 150 feet.

It is found most convenient to mix the aggregate on the surface and send into the mine in cement bags, this providing a convenient quantity for emptying into the gun.

To operate the gun, having the aggregate mixed on the surface, one man is needed at the nozzle and two men supplying the machine

A cordial invitation is extended to anyone to visit the colliery to see the work done and obtain any further desired information. Meanwhile, if the foregoing facts should prove of interest to the readers, the writer shall be well satisfied.

SPONTANEOUS COMBUSTION AND UNDERGROUND FIRES IN COAL MINES—CAUSES, AND METHODS OF DEALING WITH THE SAME.

By WM. CARSON and F. CARSON.

It seems hardly necessary to say that underground fires create conditions that militate strongly against the safe, economical and efficient working of coal mines. And while the causes and methods of dealing with the actual occurrence of fires submitted in this paper may seem in some cases to be contrary to general mining practice, it may be stated that the conclusions arrived at are the result of nearly thirty years' experience in mines which have admittedly been classed as gaseous, and in which the coal seams were liable to fire as the result of spontaneous combustion.

In 1890 a paper was submitted by the late Wm. M. Shore to the Mining Conference then sitting, dealing, among other matters, with the grave dangers attendant on these fires, with the various causes to which spontaneous combustion may be ascribed, and with the steps that may be taken to overcome them. After the lapse of thirty-five years and much research, spontaneous combustion and mine fires present to-day, owing to the increased ventilation generally required in mines, a graver danger than ever.

We will first deal with the causes and indications of spontaneous combustion in cases which have come immediately before our notice in the Kaitangata mines. In the old days, when the coal was riddled at the face, and the greater part of the dross was stacked along the pillar sides in the working places, conditions were extremely conducive to spontaneous combustion. The most prolific cause in such cases was the fact that the dross absorbed heat generated by the crushing of the pillars. Very soon sweating was noticeable on the pillar side at the top of the dross heap, and then, after a few days, during which a very offensively-smelling gaseous mixture of CH_4 , CO_2 , H_2S , and varying percentages of CO

was given off, smoke made its appearance. The ordinary method of dealing with cases of this kind was either to quench the fire with water, or remove the heated coal.

In the year 1905 a very serious outbreak of fire occurred in Castle Hill Mine close to the ventilating furnace at the bottom of the upcast shaft, the origin of the fire being attributed to spontaneous combustion in an accumulation of fallen coal in old levels on the rise side of the shaft.

This fire broke out on night-shift, and was found by the official in charge only after it had a good hold of the surrounding timbers and coal. The ventilation was immediately reduced by placing a regulator on the main intake drive. At the same time an attempt was made to control the fire by means of the water supply available. This, however, proved totally inadequate, and a line of 3-inch pipes was run from the main pumping plant to the seat of the fire, a distance of nearly 2000ft. Water was then available at a pressure of 200lb per square inch, and several leads of 2-inch hose were available to play on the fire.

In the meantime matters at the seat of the outbreak had become serious, the flames by this time reaching to the top of the upcast shaft, which is 500ft deep and lined with brick. The pit-head frame was soon ablaze, and immediate steps were taken to prevent the gear from falling down the shaft. After about twenty-four hours of incessant toil, the fire was got under control, the loose coal having been shovelled out, and the seat of the fire and surrounding places thoroughly saturated with water. The greatest danger attendant on fires of this kind is interference with the ventilating air current.

In the case under review it was necessary, after the volume of air had been reduced by means of a regulator on the main intake, to further regulate it near the seat of the fire and direct the main current round a back level to the upcast shaft. This was done by means of a board and brattice stopping, which allowed the fire to be attacked from two sides simultaneously.

During a lull in operations, the general manager, Mr R. S. Jordan, and the mine manager proceeded round the back level to further explore towards the seat of the fire. It is evident that at that time there must have been some alteration in the ventilation, for suddenly there was a "blow-back," or recoil, and they were both enveloped in the full force of the smoke and gases from the fire. Mr Jordan was speedily

suffocated, and must have died almost immediately. The mine manager, however, struggled back along the road, and with assistance reached the fresh air.

The next case is one of a mine in which the coal seams were very susceptible to spontaneous combustion, and in which it is evident adequate provision had not been made for sufficient pillar to be left between the main intake and main return drives, and also between the ground worked and the main return drive.

Fires occurred in the pillared areas adjacent to the airway, and on account of the small pillars left for support, and also to the inadequate provision for dealing with these fires, the main airway where it passed through the several seams worked, soon became a source of trouble and danger. The fire very soon burned its way through the shell of pillar left for support and became a menace on the airway, which was at times charged with varying percentages of CH_4 given off from the new workings in the seams beyond. Steps were taken to deal with the fires by means of the application of water and by removing the heated coal and then filling in the openings with sand or ashes. Steel tubes were also used in places, but none of these remedies was found to be efficient. In fact, it was quite a common occurrence when travelling along the airway to meet with a fire just breaking out in the pillar side.

At the same time fires were of daily occurrence in the pillar sides and over the timbers in the main road. These fires were kept in check by means of a good water supply until they became too troublesome, when the burning and heating coal was removed and the opening thoroughly drenched with water. This system was carried on for some time, until these openings became very large, and the pillar between the main intake and return was nearly burned through. The fires then got to such a stage as to be almost uncontrollable. Resort was then made to the building of brick walls and arches on the main road where it passed through the old coal seams with a view to isolating the fires.

In the majority of cases, owing to movement in the surrounding strata, and to the fact that in some places there was a vacant space of up to twenty feet high above these arches, they proved a miserable failure.

After years of incessant fire-fighting it was found compulsory to seal off the mine until a new airway was driven from the surface. While this work was going on, several

portions of the main road were tackled and effectively secured by an entirely new method which originated with the present management. This method, which has resulted in the saving of thousands of pounds, and, we may say, in the salvation of the mine, will be described later on.

We shall now deal with what is termed a gob fire, or fire in the waste.

In all pillaring work in high seams a certain proportion of coal, more or less according to the condition of the roof, is left behind and buried by falls of stone in the waste. In coal seams such as we have in Kaitangata the coal left in the waste is a source of continual anxiety and trouble, this arising from the nature and quantity of the coal and the nature and amount of fallen roof. Where in some cases we have been able to work sections for nine months without blocking off, there are other instances where a section has been worked for only about two months, when it became necessary, owing to heating in the waste, to seal it off.

In the first instance, the coal was clean and of good quality, with a strong roof consisting of hard conglomerate, and in the second, the coal was of a rougher nature and sooty backs were very prevalent.

It has been possible at times to control a gob fire with water; but where the volume of fire-stink is great, accompanied by CO, it is always deemed wise and economical to seal off the waste. In sealing off a gob fire, especially in a gaseous mine, great care must be exercised, as there is the constant danger of CO generated by incomplete combustion, or of CH⁴ given off from the strata, coming into contact with flame from the fire and causing a violent explosion. Several cases of this kind have occurred in the mine, fortunately without very serious consequences. It has always been noticed where there has been an explosion of this kind with the consequent blowing out of the temporary stoppings, that the section being sealed off has been of comparatively small extent, and the fire has been in a fairly advanced stage near the intake.

Through practical experience we have come to the conclusion that spontaneous combustion generally in our coal seams is the result of oxidization, supplemented in many cases by the effects of crushing pillars, more especially where insufficient pillar has been left between the roadways.

We have had experience of small roadside fires, where practically only a few shovelfuls of small coal had been lying

in the side of a roadway. In a matter of a few weeks from the time this coal had accumulated, smoke could be seen rising, and when the heap was stirred up with a shovel, the fire immediately burst into flame. This, we believe, more than confirms the theory of oxidization. Again, we find that some seams, and even different parts of the same seam, are more liable to fire than others.

We have instances where fires have occurred in what are termed sooty backs in the coal seam, and have burned their way completely through the pillar before being effectively dealt with. The coal on both sides of the seat of the fire, although considerably charred by the fire, gave no further trouble after a liberal application of water had been made.

Coal seams of a friable nature and intersected at frequent intervals by natural soft backs, are in our experience, those in which spontaneous combustion is most likely to occur.

The average composition of Kaitangata coal is:—

Fixed Carbon	38.00
Hydro-carbons	39.96
Water	18.22
Ash	3.82
Sulphur	0.40

The high hydro-carbon content seems to increase its tendency to fire, and this is borne out by the fact that dross stacked on the surface may be seen burning after it has lain a few weeks.

The main sources of danger in dealing with underground fires lie in the fact that gases, both inflammable and non-inflammable are given off.

Besides danger of explosion, there is great risk of workmen in the mine being overcome and suffocated by noxious gases. White damp or CO is the dreaded enemy of the miner, because of its difficulty of detection, and the fact that a small percentage in the atmosphere renders the men unfit for work and may even prove fatal.

Regarding methods of dealing with underground fires, these vary according to the circumstances. Most fires, if found in the initial stages and reasonably accessible, may be dealt with by a liberal application of water, and removing the heated coal. In other cases it is necessary to isolate the seat of the outbreak by means of stoppings, but in extreme cases it may be necessary to seal up the mine. In applying

water to a fire, men require to be judicious. We have had several experiences where men, in their eagerness, have plunged the nozzle of the water hose into a heap of burning coal, with the result that there was a sharp explosion, and they suffered severely from flying steam and embers. Then again, an inadequate water supply is very often worse than none. We have had numerous instances where, when water was applied to fires in insufficient quantity, the effect was to considerably increase the blaze. In fact, in one instance, one of our old deputies considered there must be kerosene in the water, for instead of subduing the fire, it apparently assisted combustion.

We will now consider the case of a fire, the result of spontaneous combustion, where it has been necessary to seal off with stoppings in order to control and extinguish the fire.

In all mines with coal seams liable to fire, it is a wise thing to have the workings divided into comparatively small sections with few openings, so that each section may, in the event of fire or heating in the waste, be completely isolated from the others. While the work of extracting the coal is proceeding, it is expedient that suitable stoppings should be prepared at suitable points for the expeditious sealing-off of any fire that should occur. It is sometimes necessary, owing to unforeseen circumstances, to build stoppings on short notice where no preparations have been made. The usual practice in such cases is to build temporary stoppings with boards and clay, and afterwards reinforce these with buildings of sand or ashes.

In sealing off a section it is held by some authorities that the outlet stopping should first be closed, and then the inlet one. With this procedure we must disagree, for in numbers of cases in our experience, it has been practically impossible to get near the outlet until the inlet has been closed up. There is also the added danger when CH_4 is present in cavities in the roof, that closing the outlet will have the effect of taking pressure off the air, thereby allowing the gas to come in contact with the fire. This has happened several times in our experience with more or less serious results. The best method, we find, is to prepare both inlet and outlet stoppings and close them simultaneously.

Much has been said of late in favour of brick or concrete stoppings for sealing off fires, but we find from experience that these, unless supported by a good backing of sand or ashes, are an absolute deception, for in a comparatively short time the fire makes its way round the sides or over

the top. The most efficient fire-stopping we have found is one about four feet thick, built with well-tamped ashes. The preparation for the stopping is a very important matter, it being necessary, in order to get a thoroughly tight job, to see that all loose coal on the roof, sides, and floor, is properly trimmed off. Where there is movement of the strata and the floor is inclined to heave, we have found a stopping of from four to six feet thick and composed of logs and sand or ashes, to be of great service. This stopping acts also as a chock, and has been used with great success almost on the edge of the waste. Strict attention must be paid in the building of these stoppings to see that the logs are properly embedded in the sand, there being at least nine inches of sand between the logs and roof sides and floor, and six inches between the logs.

Up till 1906, when dealing with fires on the main roadways and airways in the Kaitangata mine, great difficulty was experienced on account of the presence of fires along the main intake and main return airways. An attempt had been made to seal off the fires by means of brick arches about two feet in thickness. Owing to heaving bottom and the fact that there were large cavities above these arches, there were very soon signs of fracture in the roof of the arch, the brick-work becoming crushed and ineffective as a stopping. It was, in the first place, with a view to strengthening one of these arches, that the manager and engineer of the mine conceived the idea of using steel rings made of forty-pound railway rails, securely fish-plated at the joints, and lagged with two-inch planking and packed behind with ashes. The experiment was so successful that the use of these rings was extended to other bad portions of the roadway, with a like satisfactory result.

After the new airway had been driven from the surface, it was found necessary to secure a part of the main roadway where fire had been very troublesome, and where large falls had occurred while that section of the mine had been sealed off. The roadway was first timbered about eleven feet high, the timbering being followed closely up with rings of steel rail, nine feet wide and eight feet high, set at eighteen-inch centres, and lined with quarter-inch steel plates securely bolted together. As the work progressed, these were firmly packed on the sides and roof with a layer of from two to three feet of sand, which prevented air from reaching the fire, and also acted as a cushion, so that the rings took the squeeze gradually. Many hundreds of feet of this work

have been carried through, and in every instance where the packing of the sand has been carefully supervised, all further trouble has been eliminated.

A striking illustration of the efficacy of this method of sealing off a serious fire in a main haulage road is to be seen in No 1 Kaitangata mine. In this instance, owing to the fire, which, by means of water and brick walls, had been kept under control for a number of years, gradually becoming a menace to the safety and future development of the mine, it had been found necessary to drive a deviation in stone round the affected section, at a cost of several thousands of pounds. Apart from the actual cost of driving this roadway, there was also the fact of its use being very detrimental to the haulage in the mine, there being several bad turns and a considerable grade to negotiate. With a view to installing the endless rope system of haulage in the mine the management decided to re-open the sealed-off portion of roadway and attempt to secure it with steel rings and plates. The fact that in the early working of the mine and at this particular place a heading had been driven to the rise in the seam in direct continuation of the main roadway made the work doubly difficult. Fire made its appearance shortly after the intake stopping was opened, but was successfully kept in check by means of a good water supply; and after about two months of strenuous work, during which some thousands of tons of burning debris were removed and the rings and plates placed in position and packed with sand, the job was completed without accident.

This work has now stood the test of over sixteen years without signs of movement, and has been the means of great saving to the company, as it gives a straight haulage on the main drive, a total distance of about 4000ft. (See plates).

Before passing on from the causes of, and methods of dealing with mine fires, there is one experience with white damp which we would like to mention.

In 1921 we had occasion to deal with a fire resulting from spontaneous combustion, and which had broken out above the timbers on a main haulage road. Owing to a fall from the roof, great difficulty was experienced in reaching the seat of the fire, the only means of access being on the return side. After working strenuously for a considerable time to reach and subdue the fire, it was found the outbreak was gradually getting beyond control, and although neither

(H¹ nor CO² could be detected in a safety lamp, the official in charge and the workmen on the immediate scene were suddenly rendered unconscious. It is noteworthy to mention here that inflammable gas had not been detected in this part of the mine, even in cavities in the roof, 30ft above the roadway. We arrived on the scene about this time and were just in time to see an ignition of gas. There was no violent explosion, but there was a mass of pale blue flame which travelled back the roadway against the air and along the timbers for a distance of about two chains from the seat of the fire. Steps were immediately taken to build a stopping on the intake side to isolate the fire and cut off the air. During the time this work was in progress there were ignitions of gas at frequent intervals, but as the stopping neared completion the ignitions became less frequent, until, when the stopping was completed, no further ignition occurred. The outlet stopping was then built and finished in comparatively fresh air coming from the dip section, although by the time the work was completed, the men immediately employed were suffering considerably from the effects of a gas which could not be detected in the safety lamp. From the effects on the men and experiments with a canary, we are fully convinced the noxious gas predominant must have been CO, and there must have been a considerable percentage to have caused an ignition.

Careful tests were made, both on the return side and intake during operations, but no CH⁴ was discernable.

In reopening a section after it has been sealed off for some time on account of fire, we find the safest and best method is to first open on the intake side and advance towards the seat of the fire, carrying ventilation by means of brattice. When this system is adopted the air is prevented from circulating in the inaccessible portions of the workings, and it is possible by keeping a stopping in advance of the immediate scene of operations, to reopen with the utmost safety. During the progress of the reopening operations, it is expedient that no time be lost in following on with the work and securing the ground until the fire can be isolated or effectively dealt with.

Should both intake and outlet stoppings be opened simultaneously, there is grave danger that before effective measures can be taken to suppress it, the fire may have broken out worse than before, necessitating again sealing off, with the attendant danger of a blow-out.

In all cases prevention is better than cure and, with a view to minimising the risk of underground fires with their attendant dangers, we consider that sufficient pillars to prevent undue tendency to creep be left adjacent to all main roadways and airways, and that throughout the workings the pillars be kept as large as is economically possible. All dross should be sent out of the mine, and no refuse allowed to accumulate on the roadways. Disused roadways and inaccessible parts of the workings should be sealed off, and good ventilation circulated throughout the mine.

Much has been said of late regarding rescue apparatus and its use in mines, but we are convinced that the use of this apparatus would be a menace to the safety of all but thoroughly trained men of great intelligence. In all our experience we have found, even in our most difficult situations, that where the officials in charge are experienced and men of sound judgment, there is little difficulty in having the work carried out by ordinary workmen. Smoke helmets, connected to the compressed air supply, and electric lamps, have been used on occasions, but men using these require to be under the strictest observation.

In reopening a mine after being sealed down through some serious cause, or in rescue work after an explosion, it would be a wise precaution to have a set of rescue apparatus and trained men available on the spot. Examination and exploration of the mine with other than the approved flame safety-lamp is a procedure which should be discouraged.

In conclusion, we are convinced that in all mines liable to fire as the result of spontaneous combustion, especially where inflammable gas is given off in the working of the coal-seams, it behoves the managers to take a very active interest in the underground workings of the mines, and it is incumbent on them to make frequent inspections at irregular intervals, quite apart from the mine officials' daily examinations.



INVESTIGATIONS ON THE BRIQUETTING OF ZEALAND COALS.

By W. H. A. PENSELER, B.Sc., B.E.

INTRODUCTION.

The accumulation of slack coal produced at the coal mines in New Zealand made it necessary to find a use for this product, and the Mines Department, deciding to undertake research work on the briquetting of these coals, installed a small experimental press at the Dominion Laboratory.

The coal briquetting investigations summarised in this paper were carried out by the writer under the direction of and in collaboration with J. S. Maclaurin, D.Sc., Dominion Analyst, and W. Donovan, M.Sc., Assistant Dominion Analyst.

The proximate analyses of coals and their calorific values shown in the tables accompanying this paper were determined by S. H. J. Wilson, M.Sc., of the Laboratory staff.

TECHNOLOGY OF COAL BRIQUETTING.

A brief description follows of the modern method of briquetting coal.

Raw Material.—That portion of the product of a coal mine designated "slack" is the common raw material available for briquetting. In many cases, particularly where the coal is anthracitic or non-coking (e.g., lignites), this slack is thrown on the dump and hence represents a loss which has to be balanced by an increase in the price of the screened lump coal. The briquetting of this waste coal would mean the utilisation of the entire mine product.

Binders.—Many kinds of binder have been suggested but a small number only are in use at present.

The binders commonly used in coal briquetting are:—

- Coal tars and pitches.
- Petroleum products (bitumens).
- Starch, flour, and similar glutens.
- Molasses and other pectin compounds.
- Sulphite liquor from paper mills.

Crushing and Screening of Slack.—Except in the case of very friable coals, where it may pay to briquette the entire product of the mine, crushing of the raw material is unnecessary, though any oversize in the slack should be removed by a revolving trommel and burnt under boilers, etc. The material passed on to the briquetting plant is usually that which will pass an 8 or a 12 mesh sieve.

Drying of Coal.—The reasons for drying the coal are:

1. Wet material is difficult to feed.
2. A marketable briquette should contain as little moisture as possible.
3. It is of advantage to feed material to the mixing equipment hot as well as dry.

Steam driers and furnace gas driers of several types are in use. Steam driers of the table (Cainsdorf) and tubular (Schulz) types are extensively used in connection with the drying of lignite prior to briquetting.

For ordinary briquetting practice the following types of furnace gas driers are used:—

1. Direct heat rotary driers and Zwoyer driers. The former consists of a simple rotating cylinder provided with flights for lifting and spreading the material across the interior through which the hot gases pass.

In the Zwoyer drier the hot gases pass through a trough containing rotating paddles stirring up the coal.

2. Semi-direct heat driers—e.g., the Ruggles-Coles Class A. This consists of a rotating cylinder with a centrally located heat flue attached to the cylinder longitudinally and rotating with it. The hot gases pass down¹

the central flue and then through the space between the two concentric cylinders, in which space the coal to be dried is placed.

3. Indirect heat driers, in which the gases are kept from any direct contact with the material to be dried. This type is very little used in fuel briquetting.

Cracking or Melting of Binders.—Hard pitch is usually crushed or "cracked" so that it may be mixed with the coal in a powdered form.

Soft pitches and bitumens from a storage tank heated by steam coils are mixed with the coal in a liquid form.

The hard pitch process is better adapted to piston and mould revolver presses, while the liquid binders are used with rotary presses. It has not been possible to reduce the amount of hard pitch employed to as low a percentage as is possible with melted liquid binders.

Proportioning and Mixing of Coal and Binder.—The function of the binder is to coat the particles, to fill up voids, and by its cementing properties to hold the briquette firmly together. The amount of binder will depend on the amount of surface to be coated, which, in turn, will depend on the size of the particles. Again, various binders are required in different percentages. The character of the coal has also to be taken into account.

To obtain the maximum efficiency from any binder it should be as fluid as possible during mixing, so that all the particles of coal may be coated with a minimum of binder. The maximum strength of the briquette will be obtained only when all the particles of coal are thus coated; after this there is little further gain in strength with additional binder.

In general, when using pitch the amount necessary varies from 7 to 10 per cent., and when using a bitumen from 5 to 8 per cent. As mentioned, hard pitch is mixed with the coal in pulverised form (e.g., the two crushed together), while melted binders are sprayed on to the coal.

In most plants the coal and binder, properly proportioned, are mixed in one or more paddle mixers, consisting of a horizontal trough with a longitudinal shaft carrying

blades or paddles. The "flux" is mixed, and steam is injected in order to temper the mix and help the binder keep its fluidity. To obtain thorough mixing several such paddle mixers, placed in series, are necessary, but when a vertical fluxer or malaxeur is used above the press one paddle mixer is sufficient.

Mastication.—This is a feature of what is known as the "Dutch Process." The mix from the paddle mixers or fluxer is subjected to an intense kneading action under heavy rollers in a special edge-runner with stationary pan and revolving rollers. By means of an adjustable plough or scraper the material is turned over and gradually forced through a discharge opening in the centre, having been ground or kneaded six or eight times. The width and weight of the rolls vary to suit the nature of the coal being treated. As a result of this treatment the coal and binder are thoroughly incorporated, forming a relatively dry plastic substance as opposed to the wet and sometimes sticky mass coming from the mixers. The distribution of the binder is so efficient by this kneading action that less may be successfully used than where simple mixing is employed.

Pressing. - The type of press used depends upon the adaptability of the mix fed to it as well as upon the market conditions its product is called upon to meet. A good press is essential

The two main types of press used are:—

1. Piston and mould type, producing large sized briquettes, and used chiefly in Europe.
2. Roll type, producing eggettes, boulets, etc. This is the type favoured in America.

There are numerous designs of each type.

After-Treatment of Briquettes.—Since the briquettes on coming from the press are warm and soft, cooling is necessary to harden them before transportation. Air cooling by series conveying on woven wire belts is the most approved method, though a water spray is sometimes used. When sufficiently cool the briquettes are conveyed to storage bins, and thence to trucks as required.

Briquettes made with certain soluble binders are usually subjected to a baking or carbonising process to render them waterproof; but such process is not necessary with insoluble bitumen or pitch binder

Requirements of Good Briquettes.

1. Briquettes must be sufficiently tough to withstand handling and transportation They shall be hard but not brittle
2. The density of the briquettes should about equal in density the lump coal from which the slack is derived.
3. Their size and shape must be suited to their requirements
4. They must be practically waterproof and weather-proof
5. They should be easy of ignition and burn without much smoke.
6. They must retain their shape in the fire and not crumble to powder
7. The heat value of the briquettes must be at least equal to that of the fuel from which they are made
- 8 Their price must not be greater than that of lump coal

Advantages of Briquettes.—The following statements are quoted from Bulletin 58, U S Bureau of Mines:—

—Advantages of Briquettes over Natural Fuel —

“Briquettes, when properly made with a suitable binder, possess the following advantages over raw fuel:

- 1 The even size of the briquettes permits a more regular and thorough combustion in the firebox or furnace.
2. They produce much less smoke, and, in many cases, practically no smoke. This feature of briquettes is more noticeable with the smaller sizes than with the large rectangular blocks. On account of the number of flat surfaces the latter tend to pack together, thus preventing free access of air. If an excessive amount of tarry pitch is used some smoke will be given off.

3. Good briquettes retain their shape in the fire, and do not cake sufficiently to cut off the supply of air to the upper surface of the fire.

4. Briquettes usually burn to a fine ash without clinkering. In the briquetting process the mixing and grinding distributes the ash or foreign material, which forms lumps and layers in the raw coal. When raw coal is burned many of these lumps and layers, being too large to pass the grate, are fused into clinkers.

5. A briquette fire requires much less care than one of raw fuel.

6. The evaporative power of briquettes is greater than that of coal in its natural condition. This advantage has been found to exist at all rates of evaporation.

7. The weather-resisting qualities of many coals, especially lignites, are greatly improved by briquetting.

8. Steam can be more quickly and easily raised with briquette fuel than with run-of-mine coal.

9. Higher rates of combustion are possible with briquettes than with run-of-mine coal.

10. The loss from breakage during transportation of good briquettes is less than with run-of-mine coal. This loss should not exceed 5 per cent

11. The possibility of spontaneous combustion is eliminated if the fuel is stored in the briquetted form, and for this reason fuel in the form of briquettes is favoured by European countries.

12. The large block-shaped briquettes may be piled in regular rows and occupy less space per ton than the run-of-mine coal. However, the egg-shaped or cylindrical briquettes occupy more space than the run-of-mine fuel.

13. Briquettes have a higher heating value than the raw fuel from which they are made, by reason of the higher heating values of the binders and the loss of water, especially in the case of lignite, during briquetting."

THE BRIQUETTING OF NEW ZEALAND COALS.

Coals.—Samples, weighing about $\frac{1}{2}$ cwt of slack and small coal, were obtained from representative mines.

Binders.—The various substances tried in the course of the present investigations were:—

Organic Binders:

- Gas tar pitches.
- Bitumens of various kinds.
- Casein glue and ordinary glue.
- Flour, and mixtures of these.

Inorganic Binders:

- Clay.
- Lime.
- Magnesia.
- Magnesia cement.
- Ordinary cement.
- Sodium silicate.

Of the inorganic binders clay, lime, and magnesia were quite unsuitable, as they gave practically no coherence, apart from adding seriously to the quantity of ash and hindering combustion.

Magnesia (or Sorel) cement gave good briquettes, but the quantity required, as also with common cement and sodium silicate, was excessive. The last-named binder had the additional disadvantage of seriously lowering the fusion point of the ash. The time for the setting of the inorganic binders also is in general too long, and the briquettes require to be dried after manufacture.

Of the organic binders the glues, in conjunction with a hydrocarbon binder, gave good results, but the cost was prohibitive. Flour behaved similarly.

The best results were obtained by the use of pitch or a bitumen binder. Pitch is cheaper than a bitumen, but the latter gives a briquette that is tougher and more resistant to handling, and for the same strength entails the use of a less amount. A pitch-bound briquette, however, is quite satisfactory.

The quantity of binder required per 100 parts of the coal is called the "mixing ratio." Thus a mixing ratio of 5 (abbreviated to "5 M.R.") means five parts by weight of binder to 100 parts by weight of coal.

Experimental Press.—The laboratory press used is shown in the accompanying photograph. It is an hydraulic press capable of giving pressures up to 30 tons per square inch, the moulds and plungers being varied as required.

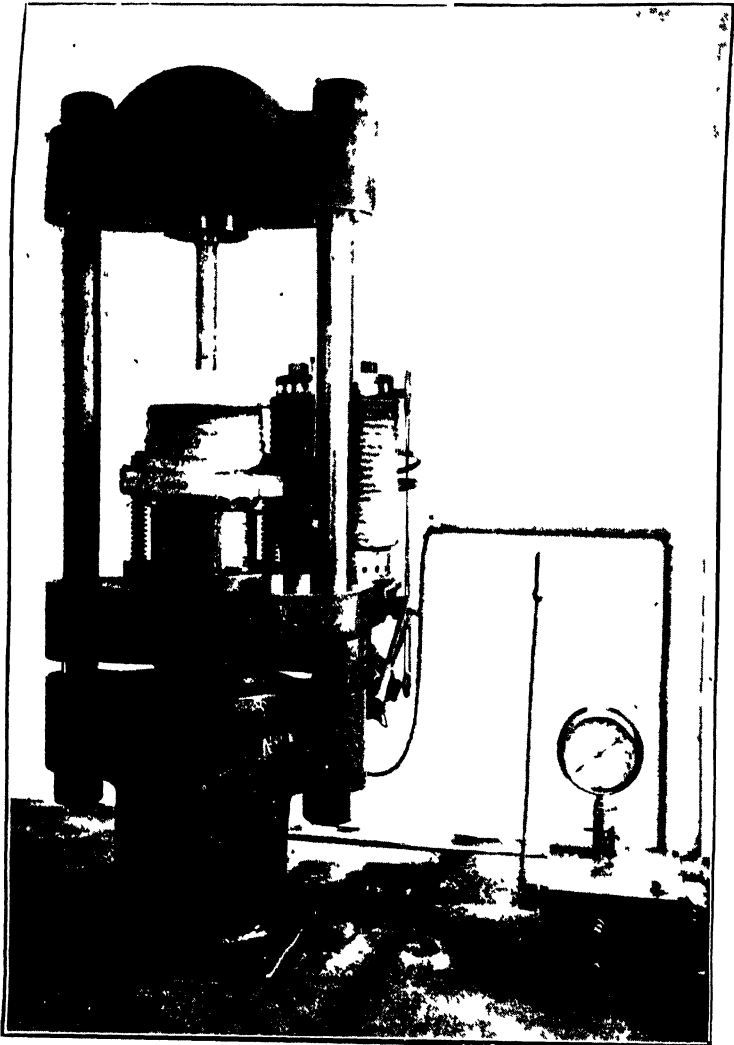


FIGURE I: PRESS

Hot oil from the heater at the side can be pumped through a jacket round the mould, which is thus kept at any required temperature for briquetting

In making a briquette 50 grammes of the crushed coal with the desired amount of binder are heated in a mortar in a water or air oven till the binder is melted. The binder is then thoroughly incorporated with the coal by mixing with a pestle, the hot mix transferred to the warm mould of the press and subjected to the required pressure

Testing of Briquettes.—Tests by breaking in the hand are unsatisfactory

Tumbler Test. To obtain an indication of the behaviour of any briquette under transport conditions a tumbler, modelled on that described in Bulletin 37, U. S. Bureau of Mines, was made. It consists of a cylinder of stout galvansed iron 12 inches in diameter and 15 inches long, provided in the interior with three longitudinal vanes 2 inches high and is mounted horizontally in bearings on a wooden

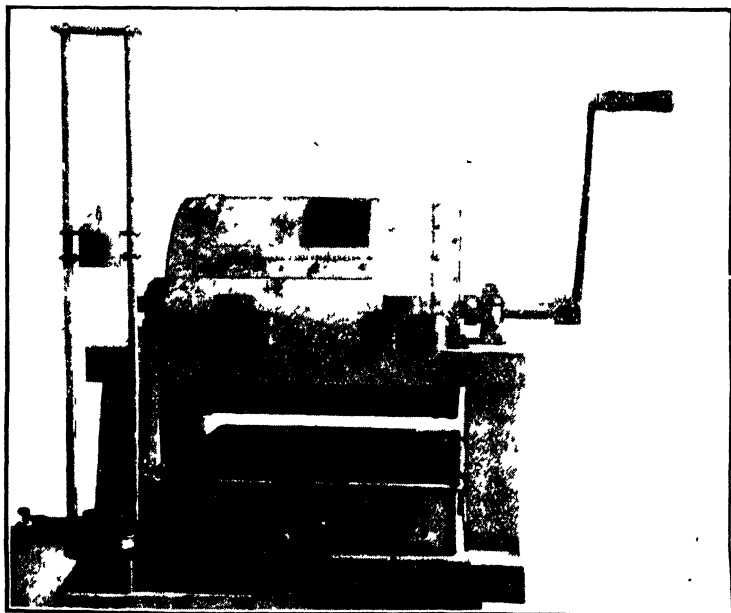


FIGURE II: TUMBLER

frame. Twenty weighed briquettes and twenty hardwood blocks of similar size and shape are placed in the drum, which is rotated for two minutes at 30 r.p.m. After rotation the briquettes are sifted on a 1-inch screen; the portion remaining on the screen is weighed and expressed as a percentage of the original weight, the figure so obtained indicating the comparative resistance to abrasion such as would occur in transport.

Compression Test: Some briquettes were subjected to a compression test by pressing a briquette between the plunger of the press and a plate placed over the mouth of the mould. The maximum pressure required before collapse of the briquette is read on the gauge. This test was discontinued, as it was shown that the results were affected by slight changes in temperature. This test, however, brought out the main difference between a pitch and a bitumen-bound briquette. The former would crumble and give a sudden collapse, while the latter would give only a gradual squeezing out of the briquette under pressure.

Drop Test: This was substituted for the Compression Test. A wooden cylinder of the same diameter as the briquette, shod with brass, and weighing 120 grammes, was dropped from a height of 50 cms. on to a briquette placed on a steel plate. The number of blows necessary to disintegrate the briquette was noted, and the average of five tests was taken in each series. The briquettes made from some coals would shatter and crumble with indistinct fracture; others would give a sharp, clean fracture with no crumbling. "Numerical" comparisons between briquettes of different coals were therefore difficult, but when using one coal with varying amounts of pitch the results were of the same order as those obtained by the Tumbler Test.

Burning Test: The briquettes after testing in the tumbler were burned in a "Register" grate and their behaviour noted. In the tables of results given later the efficiency of the briquettes is indicated by the letters A, B, C:—

- A: Briquettes stand up well in the fire and form a hard coke.
- B: Briquettes remain fairly hard in the fire, but are rather tender and crumble easily when poked.
- C: Briquettes unsatisfactory—crumble to powder as soon as hot and choke the fire.

Weathering Test: In the course of this laboratory investigation it was impracticable to make sufficient briquettes for weathering tests. It is evident that briquettes made with the requisite amount of pitch or bitumen binder will stand up well to weather conditions, though a slightly increased quantity of binder would be necessary where the briquettes have to withstand long exposure. Briquettes made without added binder, though better than the original coal, are not so satisfactory as, say, a pitch-bound briquette.

The results of the tests will be taken in three sections, depending on the class of coal:—

- (a) Coking coals—e.g., those of the West Coast of the South Island.
- (b) Sub-bituminous or "brown" coals—e.g., Waikato field.
- (c) Lignites—e.g., those at Matura.

—(a) Coking Coals —

The following coals were tested:—Greymouth coalfield: Paparoa, Paparoa Coal Company; Blackball, Blackball Coal Company; Rewanui, State Coal Mines; James, State Coal

TABLE I.
ANALYSIS OF COALS.

COAL	Paparoa	Blackball	Rewanui	James	Reefton	Westport	Westport-Stockton.
Fixed Carbon	76.57	43.95	58.96	34.30	43.06	59.78	56.00
Volatile							
Hydrocarbons	19.71	44.81	36.73	49.72	45.32	34.54	39.18
Water lost at 100c	0.86	3.84	0.89	5.76	8.95	0.80	2.42
Ash	2.86	7.40	3.42	10.22	2.64	4.88	2.40
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total Sulphur	0.39	4.26	0.34	5.51	4.73	3.96	4.75
Calories per gram	8,519	7,030	8,292	6,669	6,530	7,910	7,839
B.T.U. per lb	15,351	12,555	14,925	12,005	11,753	14,238	14,110
Evaporative Power	15.91	13.12	15.47	12.44	12.18	14.76	14.63
Character of Coke	Very Swollen	Compact Hard	Swollen	Dense, Hard	Dense pul- verulent	Swollen	Swollen

Mines. Inangahua coalfield: Reefton, Reefton Coal Company. Buller coalfield: Westport, Westport Coal Company; Westport-Stockton, Westport-Stockton Coal Company.

Paparoa Coal.—This semi-anthracitic coal has a lustrous black colour and is very friable; the dust is somewhat flaky or “graphitic” in texture. The briquettes made with both 7 and 8 M R. of pitch are of good appearance, smooth and hard, and stand up well in the Tumbler Test. In the Drop Test they break more easily than briquettes made from other coals, but the fracture is clean and sharp, with a smooth, shining surface in which individual particles of coal cannot be distinguished. The briquettes are considerably harder and tougher than the original coal. They burn well without becoming friable, but swell slightly and stick together.

Blackball Coal—This is a duller and harder or tougher coal than the Paparoa. 8 M.R. of pitch was found necessary to give a good briquette. The briquettes burn well, swell slightly, and adhere somewhat to one another.

Rewanui Coal -- This coal has a lustrous appearance and is friable. 7 M R. of pitch gives a satisfactory briquette, which on burning becomes at first slightly friable, but soon hardens when the coal starts to coke, swells somewhat, and adheres to the other briquettes, giving a very good fire.

From Table 4a it will be seen that 5 M R. of Petrolastic cement is roughly equivalent to about 8 M R. of pitch

James Coal – This is a very tough coal, and is unusually high in volatile hydrocarbons. Owing to the “dry” nature of the coal, at least 8 M.R. of pitch is necessary to give a satisfactory result, though more would be of advantage. The addition of pitch improves the appearance of the slack, which, originally brown, becomes black when briquetted. On burning the briquettes soften at first and are somewhat friable, but become hard while still black in colour. Owing to the high volatile content of the coal the briquettes crack radially during burning and finally break into three or four large pieces without, however, crumbling. They also ignite easily, do not fuse together, and would be eminently suitable for domestic fuel.

Reefton Coal.—Much slack is produced from the Reefton coals. With the sample tested, 8 M.R. of pitch was required to give a satisfactory product. On burning, the briquettes behave similarly to those from the James coal, but do not form as hard a coke. Some of the coals from this district are very feebly caking, and would hence benefit by the addition of 10 to 15 per cent. of caking coal.

Westport Coal.—This class of coal is friable and gives results somewhat similar to those of the Paparoa coal. 7 M.R. of pitch gives good briquettes, which soon harden in the fire, swell, and fuse together. These properties of swelling and fusion necessitate frequent poking of the fire, and could be reduced by the addition of a percentage of non-swelling coal.

Westport-Stockton.—The coal tested gave results similar to those obtained with the Westport coal; 7 M R. of pitch was found necessary

TABLE II.
CALORIFIC VALUE OF BRIQUETTES.

Coal from which Briquettes made	Paparoa	Black- ball	Rewa nui	James	Reef- ton	West- port	West- port- Stock- ton
No. of Expt. ...	36	40	29	27	39	32	34
Calories per gm ...	8565	7460	8375	6868	6852	8053	8004
B.T.U per lb.	15416	13427	15075	12363	12333	14496	14408
Evaporative Power	15.98	13.92	15.63	12.82	12.78	15.03	14.94

TABLE III.
GRADING ANALYSIS OF COALS AS RECEIVED
AND AS BRIQUETTED.

COAL	Paparoa	Blackball	Rewanui	James	Reefton	Westport	Westport- Stockton.
As Received							
on $\frac{1}{4}$ in. sieve	39.4	49.5	26.3	42.3	55.4	17.0	Nil.
„ $\frac{1}{8}$ in. „	17.0	16.5	20.9	32.4	17.0	20.1	30.9
„ 10 mesh sieve	6.0	5.0	7.5	.7	4.9	7.0	14.1
„ 20 „ „	15.5	11.7	18.8	9.4	10.0	22.2	28.9
„ 30 „ „	7.8	4.9	7.5	2.8	3.7	9.8	9.8
„ 60 „ „	12.0	5.9	8.9	3.0	4.0	11.6	9.4
„ 90 „ „	1.0	3.0	4.6	1.7	2.0	5.6	4.6
Thro. 90-mesh sieve	1.3	3.5	5.2	2.7	3.0	6.7	2.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0
As Briquetted							
on 10-mesh sieve	9.8	10.3	18.9	20.9	14.2	11.7	13.1
„ 20 „ „	41.5	35.5	42.0	46.4	40.7	40.4	48.0
„ 30 „ „	15.7	14.0	12.6	9.7	12.7	14.8	13.9
„ 60 „ „	19.0	18.3	13.4	9.8	14.5	16.4	13.7
„ 90 „ „	9.7	12.7	6.1	4.9	7.5	8.6	5.4
Thro. 90-mesh sieve ...	4.3	9.2	7.0	8.3	10.4	8.1	5.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE.—For briquetting, the coal as received was passed through a $\frac{1}{4}$ in. sieve, and the oversize ground to pass this.

TABLE IV.
RESULTS OF TESTS.

COAL	Paparoa			Blackball			Rewanui			James			Reefton			Westport			Westport-Stockton		
No. of Expt.	36	37	40	33	39	30	28	26	27	38	39	32	31	34	35						
Lab. No.	661	662	667	658	654	655	653	651	652	663	664	657	656	659	660						
Amount of Binder in M.R.	7	8	8	6	7	8	6	7	8	7	8	7	8	7	8						
Tumbler Test	91.1	92.4	90.8	87.6	91.1	93.4	63.0	80.8	88.7	87.0	90.4	93.5	94.8	92.4	94.0						
Drop Test	9.2	4.4	21.0	22.0	21.4	28.2	8.6	12.4	19.0	17.8	20.2	25.6	24.4	21.8	20.8						
Burning Test...	A	-	A		A	-	-	-	A		A	A		A	-						

NOTE.—The binder used in each case was Pitch with a melting point of 45°C (Ball and Ring Method) and the briquettes were made at a pressure of 2 tons per square inch.

TABLE IVa.
COMPARATIVE RESULTS WITH A PITCH AND A
BITUMEN BINDER.

COAL.				REWANUI			
No. of Expt.			29	30	45		
Lab. No.	..	654	655	728			
Grading Analysis :—							
On 10 mesh sieve			18.9	5.3			
„ 20 „ „			42.0	38.8			
„ 30 „ „			12.6	14.6			
„ 60 „ „			13.4	17.1			
„ 90 „ „			6.1	9.4			
Tho' 90 „ „			7.0	11.5			
BINDER—Kind				Pitch	Bitumen		
Melting Point				45° C.	68.3° C		
Amount in M.R.				7	8		
Tumbler Test				91.1	93.4		
Drop Test				21.4	28.2		

NOTE.—The bitumen used was Petrolastic Cement xx 21-30 Pen. as supplied by the Vacuum Oil Coy. Pty. Ltd.

THE BRIQUETTING OF BITUMINOUS COALS WITHOUT ADDED BINDER.

Experiments were made on heating bituminous coals to their softening point and then pressing into briquettes. The temperature necessary ranged from 375 degrees Centigrade to 475 degrees Centigrade, depending on the coal, and a special apparatus was used in which the coal was heated and pressed. The briquettes produced were smooth, hard, compact, and of good appearance, but were very brittle and easily shattered.

Work on this line was discontinued for the time.

—(b) Sub-Bituminous or "Brown" Coals.—

The following coals were examined:—Rotowaro, Tauriri Coal Company, Limited; Kaitangata, N.Z. Coal and Oil Company, Limited; Wairaki, Wairaki Coal Company, Limited; Black Diamond, Black Diamond Coal Company, Limited; Avoca, Mount Torlesse Collieries, Limited; Whitecliffs, Steventon Colliery (Messrs Campbell and Leeming)

TABLE V.
ANALYSIS OF COALS.

COAL	Roto waro	Kaitan gata	Wairaki	Black Dia mond	Avoca	White- cliffs	Coals used for mixing	
							Liver- pool	Millerton (Old dip)
Fixed Carbon	41.76	41.07	42.86	40.05	35.72	38.53	58.89	58.28
Volatile								
Hydrocarbons	39.68	33.88	33.59	33.44	38.39	34.18	34.73	37.56
Water	15.78	16.79	16.62	22.39	15.42	20.41	1.82	0.86
Ash	2.78	8.26	6.93	4.12	10.47	6.88	4.56	3.30
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total Sulphur	0.22	0.34	0.18	0.28	4.76	0.53	0.37	4.31
Calories per gram.	5689	5339	5488	5040	5479	5077	7904	8067
B.T.U. per lb.	10240	9611	9878	9072	9862	9139	14226	14521
Evaporative Power	10.62	9.96	10.24	9.41	10.22	9.47	14.75	15.05
Character of Coke	Non- coking	Non- coking	Non- coking	Non- coking	Non- coking	Non- coking	Some- what swollen	Highly swollen

These coals are non-caking, and consequently a pitch or bitumen-bound briquette made from them, unless with a large excess of binder, falls to pieces in the fire as soon as the binder is melted. This great disadvantage must be overcome by using a binder that will in itself give rise to a coherent coke in such amount that it will keep the briquette intact during combustion. An inorganic binder will hold the briquette together in the fire, but, as was pointed out before, such binder increases seriously the ash content, besides hindering ignition and combustion. The method usually adopted is to add a certain percentage of a caking coal and to briquette the mixture with a pitch or similar binder. In burning, the caking coal swells, fuses, and forms a coherent coke which will hold the briquette together after the pitch has become fluid. It must be recognised, however, that such briquettes are at first weak in the fire while the binder is melted, but will in time harden up when the caking coal becomes coked. From this it follows that the added caking coal should coke at as low a temperature as possible, and should swell or fuse readily so as to give the maximum effect with the minimum amount used. Further, the caking coal should be ground fine so as to be distributed as completely as possible in the briquette.

This method of obtaining coherence of the briquette during the burning tests with these coals proved the most efficient. Some of the Westport coals were very suitable for this purpose.

TABLE VI.
CALORIFIC VALUE OF TYPICAL BRIQUETTES.

Composition of Briquette		Cals. per gram	B.T.U. per lb.	Evaporative Power
Rotowaro Coal	} with 5 M.R. pitch 1 M.R. casem	5,911	10,640	11.03
Rotowaro Coal 80% Liverpool Coal 20%	} with 7 M.R. pitch ..	6,411	11,540	11.96
Rotowaro Coal 85% Millerton Coal 15%	} with 7 M.R. pitch	6,402	11,524	11.94
Rotowaro Coal 50% Liverpool Coal 50%	} with 8 M.R. pitch	7,154	12,877	13.35
Kaitangata Coal 80% Liverpool Coal 20%	} with 8 M.R. pitch...	6,332	11,397	11.81

TABLE VII.
GRADING ANALYSIS OF COALS AS RECEIVED AND AS
BRIQUETTED.

COAL	Rotowaro	Kaitiagata	Wairaki	Black Diamond	Avoca
As received :—	Slack was not sent.				Coal very friable and hence broken up during transit.
On $\frac{1}{4}$ in sieve		Nil	28.3	70.0	
On $\frac{1}{8}$ in „		34.3	31.2	20.4	
On 10 mesh sieve		15.3	9.1	4.2	
On 20 „ „		24.7	15.7	4.8	
On 30 „ „		8.9	5.4	0.3	
On 60 „ „		8.9	5.0	0.09	
On 90 „ „		3.7	2.3	0.04	
Thro' 90 mesh sieve		4.2	3.0	0.17	
		100.0	100.0	100.00	
As briquetted —	Average				
On 10 mesh sieve	53 to 59	11.1	8.5	11.8	9.0
On 20 „ „	42.7	54.2	36.7	33.5	
On 30 „ „	14 to 6	14.8	13.6	13.6	13.7
On 60 „ „	14 to 16	16.0	12.0	16.8	19.6
On 90 „ „	10 to 12	7.2	5.2	9.3	9.3
Thro' 90 „ „	8.2	6.5	11.8	14.9	
		100.0	100.0	100.0	100.0

Other means with organic binders were tried. Thus the use of a glue in conjunction with pitch resulted in briquettes which stood up to the burning test fairly well. The cost of these glues, however, rendered the project impracticable.

The sub-bituminous coals contain on an average 15 per cent. or 16 per cent. of water, which, though driven off by drying at 100 degrees Centigrade, is quickly reabsorbed from the atmosphere whether the coal is briquetted or not.

Rotowaro Coal—This coal is typical of this group, and the majority of the tests were carried out on it. The results can be applied to coals of a similar nature. The addition of a caking coal was necessary to obtain coherence of the briquettes during burning, and 8 M.R. of pitch was required. A small quantity of bitumen could be used. The addition of a caking coal increases the calorific value of the briquette, and a mixture of equal proportion of this coal and a caking coal would give a product suitable for railway purposes.

TABLE VIII.
RESULTS OF TESTS ON ROTOWARO COAL.

No. of Expt.	4	5	12	7	16	10	20	19	21	22	23	24
Lab. No	490	491	508	500	512	503	529	528	534	535	536	541
Coal crushed to pass	4 mesh	4 mesh	8 mesh	4 mesh	8 mesh	4 mesh	8 mesh	8 mesh	8 mesh	8 mesh	8 mesh	8 mesh
Grading Analysis :—												
On 10 mesh sieve	25.3	21.7	12.7	26.7	6.9	39.8	11.7	12.6	11.6	12.6	11.0	12.5
" 20 "	38.8	36.4	44.4	35.2	31.6	32.0	41.8	40.5	37.3	38.1	37.8	39.2
" 30 "	12.6	14.6	13.6	11.9	13.9	9.8	13.8	14.3	14.1	13.9	14.4	13.3
" 60 "	12.9	14.5	14.8	13.0	19.3	9.7	15.7	16.2	16.9	16.8	16.9	16.2
" 90 "	5.4	6.3	6.9	6.1	12.1	4.2	8.1	7.8	8.7	9.3	8.8	8.5
Thr. 90 "	5.0	6.5	7.6	7.1	16.2	4.5	8.9	5.6	11.4	11.3	11.1	10.3
Caking coal (kind)	...	...	...	...	...	...	...	...	...	...	...	...
Added (amount)	...	...	...	...	...	...	...	...	...	...	...	...
Binder : (kind)	Pitch	Pitch	Pitch	Bitumen	Pitch & Bitumen	Casein & Casein	Pitch	Pitch	Pitch	Pitch	Pitch	Pitch
Melting Point	45°C	45°C	45°C	81°C	45°C	81°C	45°C	45°C	45°C	45°C	45°C	45°C
Amount M R,	5	10	5	5	5 1/2	5 1/2	7	7	7	8	8	8
Pressure in tons per sq. inch	2	2	2	2	2	2	2	2	4	2	4	2
Tumbler Test	60.7	92.8	63.1	91.6	91.8	94.9	83.1	84.4	85.3	88.4	89.1	90.7
Compression Test	...	...	...	...	...	...	...	...	...	...	...	...
Gauge Reading	70	130	49	62	90	73	82	75	...	...	...	...
Burning Test	C	B	C	C	B	B	A	A	A	A	A	A

Kaitangata, Wairaki, and Black Diamond Coals.—The remarks about the Rotowaro coal apply to these coals as well.

Avoca Coal —This coal is particularly friable, and requires a large amount of binder. It is also non-coking, and a caking coal should be added to make satisfactory briquettes.

TABLE IX.
RESULTS WITH OTHER SUB-BITUMINOUS OR BROWN COALS

COAL	Kaitangata	Wairaki	Black Diamond	Avoca
No. of Expt.	41	43	44	42
Lab. No.	669	683	684	682
Grading Analysis :				
On 10 mesh sieve	11.1	8.5	11.8	9.0
On 20 " "	42.7	54.2	36.7	33.5
On 30 " "	14.8	13.6	13.6	13.7
On 60 " "	16.0	12.0	16.8	19.6
On 90 " "	7.2	5.2	9.3	9.3
Thro' 90 " "	8.2	6.5	11.8	14.9
Amount of Binder in M.R.	8	8	8	10
Tumbler Test	84.7	85.6	86.0	93.2
Drop Test	13.4	14	8.2	31
Burning Test	C	C	C	C

NOTE.—The Binder used in each case was Pitch, with a melting point of 45°C (Ball and Ring Method), the Briquettes being made at a pressure of 2 tons per sq. inch

—(c) Lignites —

It is to this class of coal that the German 'Braunkohle' process of briquetting is sometimes applicable. In this process no binder is added, briquetting being effected by the liberation of a binding material in the lignite itself under the influence of heat and pressure. The lignite, which may contain from 30 to 60 per cent of water, is crushed and dried to about 12 or 15 per cent of water, the correct amount of water left being important. The warm material then passes to a press of the Exter type, characterised by a horizontal mould open at both ends. A steam-driven plunger forces the dried material through a con-

striction in this mould against the back of the previously made briquettes. The lignite is subjected to a pressure of about 24,000lbs to 28,000lbs per square inch, while considerable frictional heat is set up in the passage of the line or "rope" of briquettes through the mould. The resultant briquettes are hard and dense, and are a considerable improvement over the original lignite in heating value as well as in weather-resisting qualities. They are very suitable for household use.

It is found that some lignites can be briquetted by this method while others cannot, and investigations carried out by the U.S. Bureau of Mines show that lignites which contain more than 1.5 per cent. of material soluble in carbon bisulphide (as given by an extraction test) can be briquetted without added binder.

It should be noted that this method of briquetting is applicable to the poorer class of lignites, and is unsuccessful with better class lignites, "brown" coals, and bituminous coals.

TABLE X.
ANALYSIS OF LIGNITES.

COAL	Taratu	Mataura	Bannock- burn	Omokoroa	Charleston	Morwell
Fixed carbon	34.11	23.59	25.62	24.85	30.87	29.11
Volatile hydrocarbons	36.31	32.98	37.53	32.88	41.77	37.94
Water	26.20	38.13	28.81	27.81	23.66	31.33
Ash ...	3.38	5.30	8.04	14.46	3.70	1.62
	100.00	100.00	100.00	100.00	100.00	100.00
Total sulphur ...	3.43	0.50	0.50	0.30	5.71	0.29
Calories per gram.	5155	3514	4304	3609	5170	3909
B.T.U. per lb. ...	9279	6325	7746	6496	9306	7036
Evaporative Power	9.62	6.56	8.03	6.73	9.65	7.29

The Morwell lignite analysed was partly air dried.
The lignite in situ contains from 50 p.c. to 60 p.c. of moisture.

Also, with the experimental press used in these tests, it was not possible to simulate the conditions obtainable in an Exter press. Consequently in those cases where the results obtained are at least promising, larger scale tests on a suitable press should be carried out.

The lignites tested were:—Taratu, Taratu Coal Mines; Mataura, Mataura Lignite Mine; Bannockburn, Bannockburn Coal Mining Company; Omokoroa, Outcrop at Tauranga Harbour; Charleston; Morwell, Morwell, Victoria.

Morwell Coal.—A sample of this coal, which is being briquetted successfully without binder in Victoria, was obtained and tests carried out on it for comparison with New Zealand lignites. The coal as mined contains from 40 per cent. to 60 per cent. of water, and is a poor quality lignite of an earthy brown colour. Good briquettes were made after the requisite amount of drying.

Taratu Coal.—This coal is intermediate in general characteristics between a lignite and a sub-bituminous coal. It has a low percentage of extract in carbon bisulphide, and it could not be briquetted satisfactorily in the same way as the Morwell coal, but by keeping the pressure on the briquette in the mould for a short time, releasing, and again repeating the pressure a good briquette was obtained. This indicates that tests should be carried out on a full-size machine, where the conditions are different from those obtaining in the Laboratory press.

Mataura, Bannockburn, and Charleston.—These are better grade lignites than the Morwell, and have a black colour and fresh fracture surface. Fair briquettes, though not so good as those with Morwell coal, could be obtained, and better ones when using the double-press method mentioned above.

With these coals, as well as with the Taratu, the bond between the particles does not appear to be the same as with the Morwell coal. A fracture surface in the latter shows an apparently homogeneous mass, whereas in the former it is distinctly granular.

In general, finer grinding and a higher temperature of pressing would be necessary for the New Zealand lignites.

CONCLUSIONS

—(a) Coking Coals —

- 1 It is possible to make good briquettes from these coals with a pitch binder. In laboratory tests 7 or 8 M.R. was necessary, but slightly more may be required in actual practice.
2. With certain coals, blending would be advantageous to produce a briquette with the best possible burning properties.
3. The most efficient plan would be to establish a main briquetting plant which could utilise the slack from the various mines. The situation of such a plant, whether, say, in Wellington or in the Greymouth or Westport districts, depends on factors which cannot here be fully discussed.

—(b) Sub-Bituminous or Brown Coals.—

- 1 It has not been found possible to briquette these coals satisfactorily without added binder
- 2 Good briquettes can be made with the addition of a strongly caking coal and the use of a pitch or similar binder.
- 3 The question of cost is rather complicated owing to the necessity for transportation of the caking coal from the West Coast of the South Island.

—(c) Lignites—

Briquettes can, in some cases, be made from this class of coal without added binder, though it seems unlikely that the cost of manufacture would permit of competition with better class unbriquetted coal, except in one or two special cases.

As regards costs, it would be advisable to carry out large scale tests on a semi-commercial scale, in which actual working conditions could be ascertained. It would be necessary also for an investigation to be made of briquetting methods, working conditions, and costs of manufacture in commercial briquette factories.

The cost of binder is the chief item. Pitch in large lots to the extent of about 2000 tons per annum can be

obtained from the Restar Company, Wellington, at a cost of £4 15s per ton, ex. works. Pitch could be imported from England at a cost of about £6 per ton, though probably large shipments would lower the freight charges.

The landed cost of bitumen from America is about £8 10s per ton, but, since a smaller amount can be used as compared with pitch, the cost per ton of briquettes would not be very much greater.

In any case the margin of profit is not great, and, for successful operation of a plant, great attention must be paid to economy in all details, combined with a full knowledge of the technology of briquetting and an appreciation of local conditions.

NOTES ON THE AMERICAN TYPE DREDGE OPERATING AT RIMU FLAT, HOKITIKA DISTRICT.

By J. F. DOWNEY, Inspector of Mines.

The Californian dredge of the Rimu Gold Dredging Company at Rimu Flat, near Hokitika, is the most powerful yet put into commission in New Zealand. It also presents, in construction and method of working, a number of features novel to dredging in this country, and represents the last word in modern dredge design. It has succeeded in profitably treating poor and difficult ground that no other dredge we have had could possibly have dealt with. For these reasons a description of its construction and operation will be of interest.

The dredge was built to a design of the New York Engineering Company, the whole of the machinery being manufactured in America, and its cost, erected and ready for work, was approximately £100,000. It was built during the period following the war, while high prices ruled for steel, and could be installed now for considerably less than the sum mentioned.

Measured by American standards, it is not an unusually large dredge, there being a number at work in America greater in size and capacity. The dimensions of the pontoon itself do not greatly exceed those of at least one New Zealand dredge, its length being 115 feet 6 inches, beam 50 feet, and depth 10 feet 7½ inches. The pontoon of the Alexandra Lead dredge, which worked on the Molyneux River in Otago, was 125 feet long, beam 46 feet, and depth 10 feet. In all other respects this dredge differs greatly from those with which New Zealanders have been familiar. It is in the massive character of the above-deck construction, the unusual heaviness of the working parts, and the evident high power of the driving machinery that the greater size and strength of the dredge are strikingly manifested.

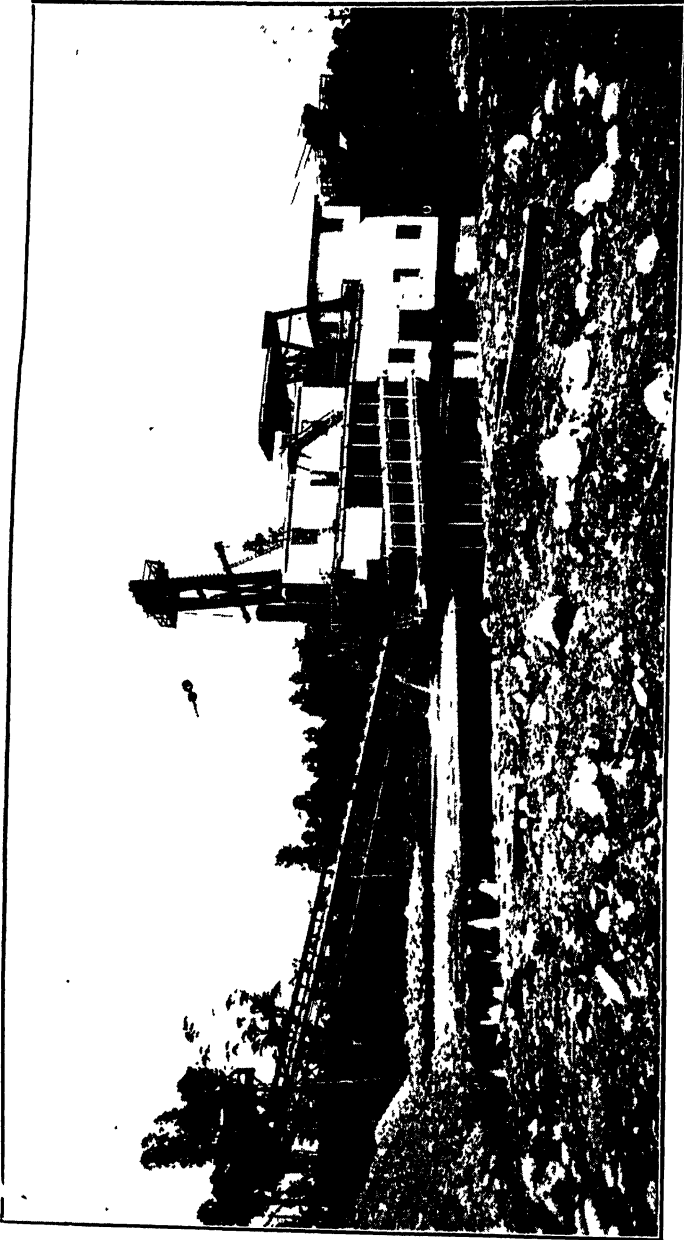


Figure 1.—View of Dredge taken shortly after work was begun.

while the most novel features are the application of electricity for all power purposes, the perfect and easy control of nearly all operations from one central position, the absence of a link between the buckets, the use of a conveyor belt for stacking, and the employment of spuds instead of head-lines to keep the dredge up to the working face.

It was known that the average values in the area it was to work were comparatively low, also that the ground was exceptionally heavy, probably heavier than any machine of the kind had ever been called upon to deal with, consequently its designers realised that its profitable employment could only be ensured by having the whole construction of such a character as would enable digging operations to be carried on almost uninterruptedly. Every effort was therefore made to provide that all parts subject to severe wear or strain should be of a size, strength, or quality of material permitting them to meet the utmost demands that could be made on them. Thus such parts as the gantry timbers, the buckets, bucket connecting-pins, tumbler shafts, and rollers are much heavier than those New Zealand dredges had. Thus the bucket connecting-pins are 6 inches, the ladder rollers 16 inches, the lower tumbler shaft 15 inches, and the upper tumbler shaft 21 inches in diameter. With the exception of the rollers, all these parts are of nickel-chrome steel. The rollers are of manganese steel. The buckets are also wholly of manganese steel. The winch is entirely of steel, and steel of some variety has been almost exclusively used throughout the whole construction. The original intention was to build the pontoon, gantries, and deck houses of steel, but it was found difficult at the time to procure it, so for these parts timber had to be used, oregon pine being mainly employed.

The main drive, winch, pumps, screen, and stacker are all operated by electric motors, as are also a sawmill and a number of machines in the blacksmith and fitting shops. The current is generated at Kanieri Forks, at the power station of Kanieri Electric Limited (a subsidiary company), and is transmitted across the Hokitika River to a set of transformers near the dredge at a pressure of 11,000 volts. These transformers are mounted on wheels, so that they can be shifted from place to place, and do not need housing to protect them from the weather. The power is stepped

down to 2200 volts, at which pressure it is utilised by the main units on the dredge. For lighting and other small work other transformers on the dredge step the voltage down to such lower pressures as required.

For simultaneous working of all the dredge machinery 550 electrical horse-power is required, the figures for each item of plant being:—

Main motor	...	...	...	200	E.H.P.
Winch	...	...	...	40	„
Screen	...	...	...	50	„
Stacker	...	...	...	50	„
Pump (high pressure)	...	...	...	125	„
Pump (low pressure)	...	...	...	60	„
Nozzle pump	...	...	..	25	„

Unfortunately, the total generating capacity of the power station is limited, and, although the whole of the motors seldom work at one time, the supply of current has not been entirely adequate for the needs of the dredge, consequently its efficiency has been somewhat impaired.

The operation of all parts of the machinery except the screen and stacker is controlled from a roomy pilot house on the upper deck, behind the main gantry. This house is glassed so that the winchman has a clear view forward of the bucket line and the working face. In it are the controls for winch and main drive, with levers for operating the various parts of the former. The main switch boards, fitted with all necessary automatic cut-offs and other modern safety appliances, are also situated in the pilot house, enclosed by heavy steel wire mesh to prevent access by any but authorised persons. The resistance frames are below the pilot house. All the motors are of the three-phase induction type, with variable speed for the digging, winch, screen, and stacker motors, and constant speed for those attached to the pumps. Until quite recently it was the practice on dredges of this kind to use constant speed for the screen and stacker motors, but it has been found that variable speed gives a better starting torque for getting these parts under way, and is particularly useful when it is necessary to start under full or over-load. The current is brought on board in a three-conductor, heavily armoured cable carried on floats. An oil switch is so arranged that it may be instantly thrown out from the pilot

house All the minor wiring is of stranded type to prevent breakages that might otherwise occur under the vibration of digging, all cables to the motors being armoured and conduits and condulets provided for the rest

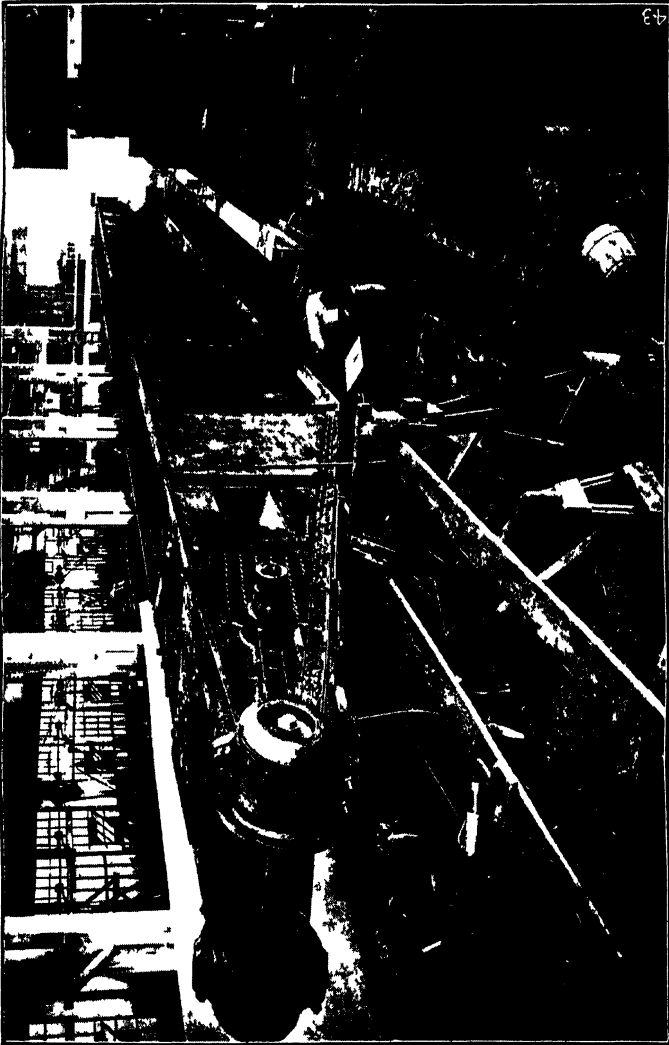


Figure 2 — View of Digging Ladder completed in Workshops

The digging ladder, of plate-girder construction, is 135 feet long, and was designed to dig to about 46 feet below water level. In actual work a face of 69 feet was dredged, but below water level the depth for which it was designed could not be exceeded. In many modern dredges of this type the lattice-girder form of ladder is in use, and engineers consider it may be quite as strong as the heavier plate-girder design, but in employing it there is always a greater danger of rivets working loose, causing collapse. In view of the very heavy ground to be dealt with, the sturdier type was adopted for this dredge. On top of the ladder a tray is provided which carries all spill from the buckets back to the digging point. When the dredge was first built the ladder was pivoted on the upper tumbler shaft, a new arrangement in this country, the old practice being to pivot it on a separate mounting detached from the bucket drive. The reason prompting this departure from the customary method is obvious. The shaft being used as a centre, the relative position of the bucket line and the upper tumbler remains constant for all depths of digging, whereas by pivoting on an independent shaft the pull of the bucket line is at different angles to the position of the ladder, hence it was thought that by pivoting in the manner adopted a greater degree of digging efficiency would be secured. The plan did not prove satisfactory. Owing to the great size of the shaft, a wide spread had to be given the forks at the ladder head, with the result that they did not stand up to the tremendous strains, and so much trouble was caused by breakages that the method had to be abandoned, and the old one of pivoting on an independent shaft returned to.

The upper tumbler is of cast steel, of the six-sided type, with short guides forming part of the casting on either side to serve the purposes of flanges, special wearing plates of harder steel being used to protect the faces of the tumbler and of the guides. The lower tumbler is round, and is of manganese steel, and is full flanged. The lower tumbler bearings are of cast steel, with cast-iron bushings mounted on the ball and socket principle and self-aligning. The bearings are tied together by a 3-inch tie-rod running through the tumbler shaft.

There are 73 buckets of 10 cubic feet capacity on the ladder, the rate of delivery is 19 buckets per minute, and no link is used between the buckets. This is now a general

feature of the big California-type dredge, the idea in adopting it being that by having the buckets directly connected one with another greater rigidity is secured, enabling very heavy ground to be dug with less wear on the bucket connections and fewer breakages in the line. In this type of dredge the buckets are generally in three parts—base, hood, and lip—with the base of cast steel, the hood of pressed steel, and the lip of manganese steel, but on the Rimu dredge there are only two parts, the base and hood being cast together, and the whole of the bucket is of manganese steel. Each bucket is furnished with two eyes in front and one at the rear, the latter being bushed. The connecting-pins, of nickel-chrome steel, are made with a lug at one end, which fits into a machined slot in the bucket base. The bucket line is driven by double gears mounted on the main gantry. This mounting of main driving wheels at each side of the upper tumbler shaft is another novel feature, and its purpose is to equalise the strain on the shaft and prevent any tendency it might have to twist. The gear wheels are 10 feet in diameter with a 15-inch face, and are cast steel with machine-cut teeth. These gears are driven by cast steel pinions having machine-cut teeth and mounted on intermediate shafts 7 inches in diameter, these being driven through another set of double gears and pinions, all of cast steel with machine-cut teeth, except that the pinions are of special high carbon steel forging. The secondary shaft is 6½ inches in diameter, and has mounted on its outer end a wrought steel rim driving pulley 90 inches in diameter and 28 inches in face which is driven from the countershaft of the ladder hoist.

The stacker is also 135 feet long, and is of lattice-girder construction, with the lower end supported at the stern of the boat so as to allow it to move up and down and also from side to side. The upper end is supported by two bridles, one near the top and the other at the middle. The heavy duty imposed on the stacker caused weaknesses to reveal themselves shortly after work was started, but some strengthening plates were put in and no further trouble was experienced. The latter will stack to a height of 50 feet above water level in the paddock. A rubber conveyor belt carries the gravel to the tipping head, several traps being arranged along its length to prevent large stones rolling back to the lower end. This belt is driven by a motor mounted near the head of the ladder, driving through a pinion with

cut teeth, which meshes into cut gear in the conveyor belt shaft. The average life of a belt has been nine months, which, considering that it will have handled $1\frac{1}{2}$ million cubic yards of gravel in the time, is very good service. Along the side of the stacker a travelling way is provided for oiling or other necessary purposes.

The screen is of the revolving kind, 46 feet in length, with an internal diameter of 7 feet. This type of screen is not always on similar American dredges, the shaking design being preferred for the treatment of certain classes of gravels, but it was thought it would be the most suitable for such heavy material as occurs at Rimu Flat. It is built up from angle iron frames, the angles being 7 inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ an inch, and two of them joined together form a tee iron which reaches from the upper to the lower trunnion rings. There are seven of these longitudinal tee iron frames, and on them the perforated lining plates are mounted. The plates are of manganese steel, and are arranged longitudinally in six interchangeable sections, with manganese steel retarding rings between each section. The perforations are tapered, $\frac{1}{2}$ an inch on the inside and 11-16 of an inch on the outside. The plates are bolted to the frames, so that any one of them can be readily removed without dismantling the entire screen. The screen is operated through the lower trunnion ring, which is mounted on a cast steel driving roller, driven by a set of manganese steel gear and pinion operated from a countershaft located on the upper deck. Side rollers are provided to keep the screen in central position, and thrust rollers, also of manganese steel, prevent any tendency of the screen to work towards the stern.

What is known as the "spuds" may be described as large steel piles, working in guides, and capable of being raised or lowered with ease. There are two of them, situated at the stern, one on each side of the outlet end of the screen. They are of rectangular section, built up of four 20-inch girder beams bolted together in pairs, the two sets being held together by cover plates. Each spud is 56 feet in length, and weighs 18 tons. At the foot they have massive, pointed, cast steel shoes. In the ordinary course of working only one is used at a time, and it is made to serve several purposes. The chief of these is to take the place of the head-lines customarily used to keep a dredge

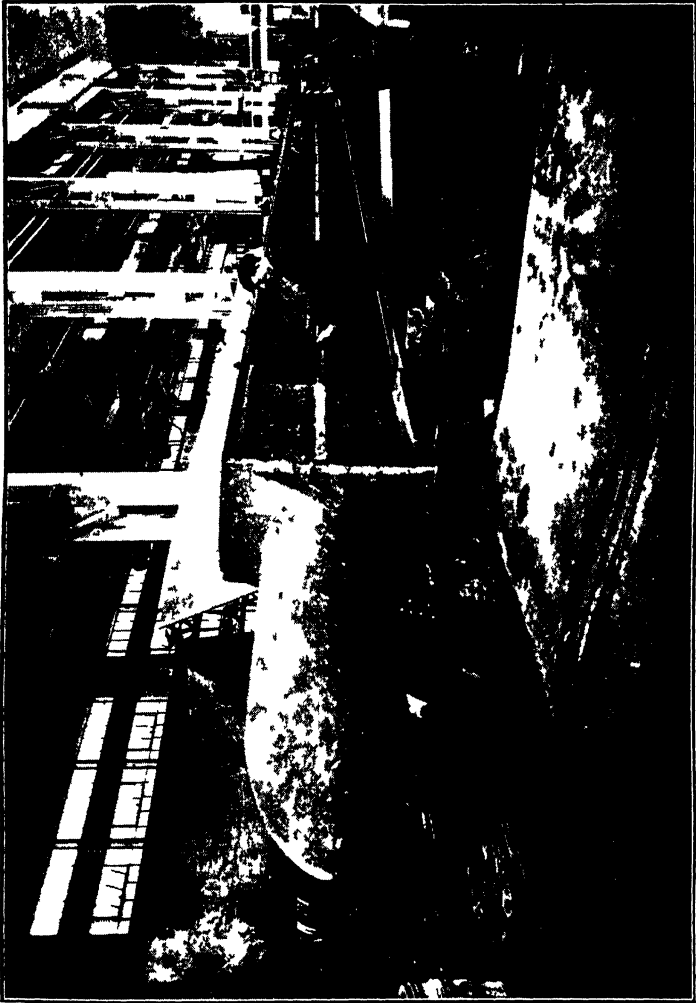


Figure 3 —Showing Spud in course of construction

up to the working face and it is claimed that they do this more satisfactorily than the older method. Greater rigidity is said to be secured and there is a lessening of the tendency of the boat to sag and surge which is so noticeable when head lines are used (especially when heavy ground is being dug) and which has so injurious an effect on certain parts of the machinery. Further uses of the spud

are to act as a pivot on which the dredge swings through an arc some 200 feet in length as it works the face from side to side, and to step the boat up to the face as required. The use of the spud as a pivot during the dredging operation necessitates a method of digging being adopted which differs from that invariably followed on our older dredges. The old style was to drag the chain of buckets upwards from the bottom of the face in a vertical line, the greater portion of the dredged material being lifted from the extreme bottom of the paddock. Using the spud, the face is worked horizontally in shallow steps or terraces, starting from the surface and proceeding downward by successive cuts until the bottom is reached. The procedure is much as follows:—Starting at one end of the face at the surface a cut from 18 inches to 24 inches deep is made right across the 200 feet. When the end is gained, the ladder is lowered the requisite distance, and on the backward travel another cut of the same depth as the first is made. The ladder is again lowered, and so the work goes on down to the bottom. Whether this method of digging is an improvement on the other method the writer is not able to state, but the management of the dredge is satisfied that its adoption enables the best general results to be obtained. It is claimed that a much larger part of the gravel is lifted direct from where it is actually broken out than would be possible with the older method, and that thus much loss of time and unnecessary expenditure of power are avoided. At Rimu Flat very heavy boulders occur in a thick layer only a few feet below the surface, and it certainly is a big advantage to be able to raise these from where they lie instead of having to fish them from the bottom 40 feet or more down.

When using the spud for stepping-up purposes the procedure is to swing the dredge, on the spud that is down, to about two-thirds of the arc of movement, then drop the other spud. The spud that has been serving as a pivot is now raised, the dredge is swung back portion of its travel, and the spud is again dropped. The spare spud is now raised, and work proceeds, the original spud still serving as the pivot for another attack on the face. The distance stepped up on each occasion is about 8 feet. The lateral movement of the dredge across the face is effected by lines carried from the bow on either side. These lines

do not pull directly on shore anchorages; they are led from the winch drums round sheaves at the bow, then through other sheaves attached to the anchors back to the digging ladder, to which their ends are secured near the bottom tumbler. This method of rigging lessens side strains on the ladder and well hole. In case of the spuds getting out of order, head-lines have to be used in the ordinary way.

The pumps are all of centrifugal type, directly coupled to motors of all-enclosed design, the high pressure having a working head of about 60 feet, and the low pressure of from 20 feet to 30 feet. The first-mentioned supplies the water for the spray pipe and jets in the screen, and the latter for the tables. The small nozzle pump is merely used in case of fire, for washing down decks, cleaning-up tables, pumping out bilge, and priming the larger pumps. All pumps are fitted with both foot and check valves, and by-pass piping is provided in each, with the necessary valves, for priming purposes. The foot valves have a grating to prevent pieces of timber, bark, etc., from passing into the pumps, and, to further assist in this direction, the suctions are all enclosed in a large wire-netted cage at the side of the pontoon.

The main winch has eight drums of cast steel, four of which are for operating the corner lines, two for operating the spuds, and two for head line and spare. The drums are 20 inch in diameter and 11 inches between flanges, and are equipped with adjustable friction clutches of the internal expansion type, and are all of them mounted on a wrought steel frame built up of 18-inch beams, tied together with 18-inch cast steel tie beams. The gears are all of cast steel with machine-cut teeth. The winch has a double reduction system of gearing, providing for two speeds for each drum. The spud hoist shaft and the head-line shaft have jaw clutches, so that they may be disengaged individually from the rest of the winch drums. All the drums have hand brakes worked from the pilot house through bell cranks, rods, etc.

For saving the gold the dredge is fitted with 4800 square feet of tables—24 on each side of the dredge, or 48 in all. It is doubtful if such a very large spread of tables is necessary. The Rimu gold is not of excessively fine character, and nearly the whole of it is caught on the upper



Figure 4.—Showing Main Bucket Drive assembled in shops.

tables quite close to the distributor box. The gold is trapped in a series of shallow Hungarian riffles in which a small quantity of mercury is placed. No appreciable amount of gold is believed to escape. The riffles are of wood, about 1 inch in depth, and spaced about the same distance apart.

The ordinary routine of work on or about the dredge may be described as follows:—All shore work, such as that in the blacksmithing, fitting, and carpentering shops, saw-milling, bush clearing, shifting of shore lines, laying of trams, etc., is done on the day shift, save in cases of extreme urgency such as breakages of plant, when the shop hands may be called on at night time, so that repairs may be made with the least possible delay. About nine men are usually employed in the shops, two at general bank work and 12 at clearing. The bush is comparatively light, is always cleared well in advance of the dredge, all stumps, dead-falls, roots, etc., being thoroughly removed. The greater part of the timber is useless, and is dragged out of the way. Such of it as can be made use of is cut up for tram rails, etc. Apart from the dredgemaster the crew consists of four winchmen, three motormen, three oilers, and four labourers, or 11 all told. The dredge is worked three shifts. It would be quite possible to carry on operations with less hands, but the management considers it advisable to keep a few extra hands, so that should any one man have to miss shift another is available to take his place, each man being trained to the duties of the position next in importance to his own.

The main object is to keep the digging operation going on with the fewest and briefest interruptions. Despite the great care exercised to see that all parts, subject to severe wear or strain, were given special strength, breakages will occur and unexpected defects reveal themselves, causing delays. Bucket lips are torn off, bolts are sheared, rivets work loose, cogs strip, shaft keys slacken, etc., all of which mean interruption of the dredge's principal work. Constant watchfulness is called for to guard against such accidents, and that great care has been exercised in this regard is proved by the unusually high percentage of digging time. Other precautions are taken to ensure not merely as constant running as possible, but also that the accepted way of digging be followed, also a close record of all delays with a view to remedying them is kept. One of these is placing in the pilot house indicators which show the current taken and the position of the digging ladder at all times during the shift. Another is that of having the winchman on each shift fill in, before going off duty, a log showing the entire course of work throughout the shift, and,

in particular, the cause and duration of all delays. Such a log would show the stoppages during the eight hours caused by breakages or defects in such parts of the dredge as the buckets, bucket drive, electrical fittings, hopper, ladder, upper tumbler, lower tumbler, motors, pumps, ladder rollers, screen, stacker, or winch, or by such operations as stepping up, removal of boulders, cleaning up of tables, shifting of lines, raising or lowering spuds, or dealing with roots or stumps left behind by the clearing gang. All the information thus furnished is tabulated regularly for future guidance.

The dredge was floated in a shallow dam, from which it started to dig in September, 1921, and to the end of September, 1925, has turned over 74.12 acres of an average depth of 46 feet, the greatest depth of face worked being 69 feet, and the greatest depth below water level 46 feet. For the three full calendar years worked, 1922-24, the average annual quantity of ground lifted was 1,387,144 cubic yards, and the average quantity per digging hour for the whole period of operation was 242 cubic yards. In view of the heavy nature of the drift this must be considered good work. No one, even amongst experienced dredgemen, who has not had the opportunity of visiting Rimu since this dredge started there can well appreciate just how heavy and difficult this ground has been. Other dredges in New Zealand have been credited with a turnover of much larger quantities in a given time, but, even if these claims could be substantiated, the material handled by them was largely sand, and it is quite safe to say that had the same dredges been placed on Rimu Flat they would have been useless. The fact that the American dredge, in the few good patches of ground entered, was able to dig as much as 356 cubic yards per hour for a month at a stretch, shows what it could have shifted in a year under more favourable circumstances.

In opening out the Rimu area a cut was first made for about three-quarters of a mile to a width of 200 feet. This was what is known as a single-width cut. On the return trip a double-width cut of 400 feet was taken, the object being partly to provide a bigger pond to manœuvre the dredge in, and partly to avoid, as far as possible, any re-handling of tailings. It can be understood that after one cut is made a certain amount of tailings must inevitably

be lifted on the free side of any succeeding one if the bottom is to be thoroughly cleaned over the whole area, and, in working a face of from 40 to 50 feet deep this would be considerable. By taking double-width cuts, the quantity of this unprofitable material it is necessary to again lift was reduced by 50 per cent., which means a saving in time, and thus more efficient and profitable work.

Practically all the boulders met are brought to the surface. In the whole four years the dredge has been in operation only one or two had to be worked over. For a time the stones were taken off the buckets at the main deck and subsequently rolled overboard near the bow. So much loss of time was entailed by this plan that a better way had to be devised, and the one the boulders are now removed from the buckets is just where the line opens out in mounting the upper tumbler. An endless chain tackle, worked by a small electric motor, and a chute built up to this point are used to slip the stones overboard amidship. The adoption of this method made a considerable saving in time, but there is still a serious loss of digging time caused by this boulder-removal part of the work, but there seems no way of avoiding it. Had a grizzly been provided for automatically removing the boulders at some point between the upper tumbler and the screen the trouble would have been eliminated, much to the advantage of the dredge, as a much larger turnover would have been ensured, with a corresponding increase in the plant's earnings. Should any further dredge be placed on the area it will probably be equipped with some such appliance, but the construction of the present one did not permit of such an improvement, and under these circumstances the plan now followed is the best possible. Only boulders exceeding in weight 4cwt. to 5cwt. are removed, the stacker handling all the rest. The buckets tip into a hopper from which the material is sluiced to the screen, where it is washed by numerous strong jets of water. All the finer portion passes through the half-inch perforations of the screen into a distributing box running lengthwise under the former, whence it is lead to the tables on either side, finally passing off, minus its gold content, through steel chutes into the pond at the stern of the boat. The coarser material from the screen is delivered to another chute that feeds it to the conveyor belt. At Rimu Flat the gravel does not



Figure 5 —View of Bucket Line with large bould
just brought up

require much washing there being no clay in it and only small portion of sand. At least two feet of the sandstone bottom is systematically taken in the dredging and this part of the material raised is all that calls for any

careful breaking up. Apropos of this lifting of the bottom, from which most of the gold comes, the method followed of working the face in horizontal slices has the advantage of ensuring that no portion is left undredged. The fact of there being so little clay or sand in the wash has been a source of some anxiety, for it has meant that as the extent of ground worked has increased the difficulty of retaining the water in the paddock has also increased, the tailing heap being so pervious as to serve but poorly as a dam. Trouble from this cause has not yet been serious, but it may become so as time goes on unless means of meeting it are devised. One way of improving the position would be by leaving strips of solid ground across the area, while another would be to lift with a sand pump the fine material now dumped below water level and distribute it over the tailings so that by percolation it would fill the interstices between the stones and thus help to hold the water back.

From the time the dredge started up till the end of September last the total working hours numbered 30 048 of which 22,507, or 75 per cent, were actually spent in digging. The proportion of digging time has varied considerably. For as much as a year it has reached as high as 86 per cent, but over the whole period delays of one kind or another have reduced it to 75 per cent, but to have secured even this proportion for four full years is in

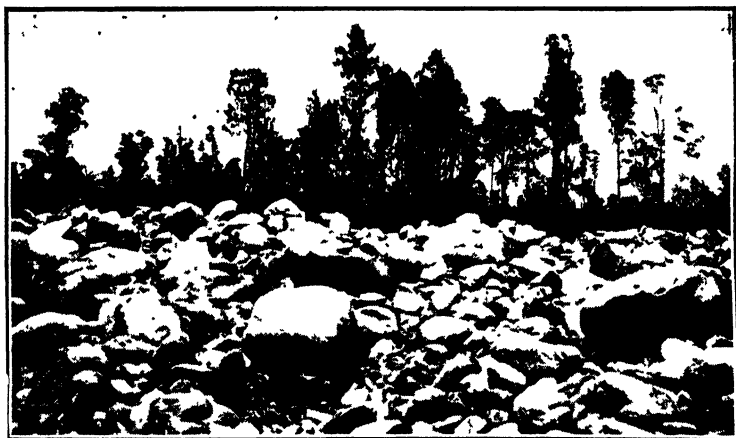


Figure 6.—Photograph of Tailing Heap, Rimu Flat, showing heavy nature of much of the ground.

itself an achievement. It is doubtful if any other dredge in the Dominion has come within even a reasonable approach of such efficiency: certainly none has done so in ground of the same character. The writer had occasion to go through the weekly reports, covering some years of work, furnished to his directors by the master of one of the most successful dredges previously operated on the West Coast, and was astonished to note how very great a portion of time was lost through breakages of machinery. Scarcely a week passed without one or more days' idleness from this cause, and it would be safe to say that of the whole working time little more than 30 per cent. was spent in digging. The experience of many of our former dredges seems to have been similar, and there can be small doubt but the failure of many of them to make good was traceable to loss in this direction, due to the plants being inadequate to meet the demands made on them.

The following table shows in detail the total loss in hours on the Rimu Flat dredge from delays of all kinds since work was started, and the percentage due to each cause:—

Cause.				Total		
				hours.		Per cent
Stepping up	...	...	...	214	...	3
Boulders	...	...	...	1,266	...	16
Buckets	...	...	...	197	...	3
Bucket drive	...	...	...	572	...	8
Clean up	...	...	...	518	...	7
Electrical	...	...	...	41	...	—
Hopper	...	...	...	305	...	4
Ladder	...	...	...	1,109	...	19
Lines	...	...	...	319	...	4
Lower tumbler	...	...	...	129	...	2
Upper tumbler	...	...	...	316	...	4
Motors	...	...	...	27	...	—
Power	...	...	...	263	...	4
Pumps	...	...	...	42	...	1
Ladder rollers	...	...	...	40	...	—
Screen	...	...	...	702	...	9
Stacker	...	...	...	302	...	4
Spuds	...	...	...	283	...	4
Winches	...	...	...	108	...	2
Roots and stumps	...	...	...	239	...	3
Miscellaneous	...	...	...	249	...	3
				7,541		100

A certain amount of this loss of digging time was not due to mechanical defects, and was unavoidable, and a further portion was due to circumstances over which the dredge crew had no control. Thus the 7 per cent. occupied in cleaning up tables, the 3 per cent. in stepping up, and the similar amount in removal of roots, etc., represented time during which digging would in any case have had to be suspended, whilst the 4 per cent. loss through failure of power was due to troubles with Kanieri Electric, Limited's, water race miles away from the dredge. The 16 per cent. loss through removal of boulders has also been impossible of escape. This leaves two-thirds of the entire delays, or roughly 5028 hours, to be credited to mechanical defects, and therefore in a sense, avoidable. The management realises that every hour lost from digging means a loss of approximately £6 in the dredge's earnings, so every effort is made to reduce the proportion, but it is difficult to say how far improvement may be expected. It is not reasonable to expect that in a plant working under such conditions breakages of machinery or losses from many of the causes mentioned can be avoided, but the indications are that in the future a considerable saving of unprofitable working time will be effected. During the past year, for instance, the loss through ladder troubles has been reduced from 19 per cent. to 5 per cent. by the carrying out of extensive reinforcement to that part. Alterations made to the bucket drive have, during the same period, lowered the loss from 8 per cent. to 1 per cent. Screen troubles have been reduced from 9 per cent. to 2 per cent. The loss through breakages of the swinging lines will also probably be eliminated. These have mainly resulted from difficulty in procuring wire ropes sufficiently flexible to work over small sheaves without undue wear.

Even with the losses the dredge has carried out its work with a great measure of success. During the whole period of operation it has turned over an average of 1,365,000 cubic yards annually, and as it was only designed to treat at most $1\frac{1}{2}$ million yards per annum it is seen that it has fulfilled in very satisfactory degree the hopes of its designers. The value of the gold won has been £183,028, equal to 8.05d per cubic yard treated. Some time prior to the Rinu Gold Dredging Company becoming interested in the area the latter was tested for various parties by key-

stone drilling, some 82 holes being put down, with results estimated, the writer understands, to approximate 1s per yard. This figure was evidently arrived at by estimating the values purely in terms of the depth and diameter of the drill-holes, no special allowances of any kind having been made. Subsequently American engineers check-bored the area, putting down a further 110 holes, together with a number of shafts, but, calculating the results obtained by means of a formulae evolved from much drilling experience in different parts of the world, they reduced the average for the whole area to 8.5d per cubic yard, so in recovering gold to the value of 8.05d it is evident that in its recoveries the dredge has also accomplished all that was expected of it and as the total working costs, inclusive of administration, have only been 5.5d per yard no further proof seems needed that for the work it was called upon to perform the dredge has shown itself eminently suitable, and has justified the confidence displayed by its owners in going to the immense expense of placing it on the field. In better ground it would unquestionably have turned over much greater quantities. At the present rate of progress it will take about 40 years to work out the property.

A good part of the area is much deeper than any yet worked by the dredge, some of it reaching 75 feet, and carrying values well above the average. Whether or not another and more powerful dredge will be put on to work these portions is as yet undecided, and it seems that the question cannot well be decided pending the discovery, within a reasonable radius of Rimu Flat of a further payable area. The point is that the putting on of a second dredge entails the provision also of a new and costly hydro-electric power plant, and, while the ground now being worked will afford profits to justify the present dredge placed on it, it is open to question if it would yield profit to an extent sufficient to warrant the installation of a second dredge, plus the power station. Should another payable area be located such extension of operations would be justified, for there would then be three dredges to take the power and a larger area from which to win the gold to pay for the scheme. The company has for some time adopted a policy of vigorous prospecting with a view to finding such an area, and has, at considerable expense, drilled a number of places that were thought to hold promise, but so far

that would be incurred in putting a modern dredge on it. The prospecting work is being continued, and hopes are entertained that a suitable run of country will be discovered. Failing the putting of a second dredge on the Rimu area, the present one can be made to work the deeper ground, all that is necessary being to lengthen the ladder, making it about 30 feet longer than it is now. This lengthening would not affect the stability of the dredge, for the bow of the pontoon now carries 30 tons of ballast to keep the boat down forward, and this weight would just about equal the extra weight that would be given to the ladder by the alteration.

The Rimu Flat area was valueless from a pastoral point of view, or even for growing timber, but the Forestry Department is planting a variety of exotic trees on the tailings, with the result that they have been found to make very good progress in growth.

In conclusion, the remark may be permitted that if there are any lessons to be learned from a study of the construction and operation of this dredge they are that, given the right type of plant, ground of very poor and difficult nature may be profitably worked; that in the design of any dredge that may now be put on to work such areas as may be left, particularly on the West Coast, care must be exercised to see that all working parts possess strength much in excess of all normal requirements; and that every effort be made in designing the dredge to so provide that all such causes of interference with digging time as have been mentioned shall be eliminated as far as possible.

THE AURIFEROUS BEACHES OF THE WEST COAST, WITH NOTES ON THEIR FORMATION, PAST WORKINGS, AND FUTURE EXPLOITATION.

By G. M. POWELL.

It is remarkable that though gold was so widely distributed over the West Coast, the two first Europeans to traverse these fields in the records of their journey never mention having seen a solitary speck of gold, yet they travelled over beaches in which it was readily visible in the sand whilst walking along. The two men referred to were Messrs Brunner and Heaphy, surveyors. Lake Brunner is called after the one, the river Heaphy after the other. The object of their quest was greenstone. That they failed to find this is not to be wondered at, but it is remarkable that they saw no gold, and it is certain they did not, or the fact would have been recorded in their diary.

The first questions that are suggested are: Why do there auriferous deposits of so-called "blacksand" on the West Coast of the South Island exist from present sea-level to a height of over 900 feet above? Whence came this "blacksand" and its associated gold? Where is or where was the matrix from which it was derived? Has the gold and "blacksand" a common matrix?

These are questions that have occupied the minds of alluvial miners on the West Coast from the beginning, and also have been of interest to geologists.

It is undeniably true that (leaving out of consideration its original situation and matrix) these auriferous deposits are due to the action of the ocean current, which, striking the shore line about opposite Hokitika, travels thence along

the coast at about $4\frac{1}{2}$ knots per hour till Cape Farewell is reached, when it again turns oceanwards, and, so far as is known, its further course has not been determined, but that is not pertinent to the subject.

Having, what might be called an ocean river, eternally moving in one direction, also with the prevailing wind assisting wave action above low water-mark, there is a continual trek northward of the lighter constituents of the detritus from the mountain ranges brought by the rivers to the sea. Were it not for this ever onward movement the gold would have been a negligible quantity, hidden in a vast accumulation of debris, which would have filled up the shallow ocean bed, and a coastal plain would have extended along the West Coast far beyond the present shore line.

Despite the many thousand ounces of gold these beaches have already yielded and the huge amount still lying contiguous to the shore line, it would probably have been of economic advantage if this ocean river had not existed, and, instead of gold deposits, the detritus from the mountains had been spread out so as to form an agricultural plain. But we must take Nature as it is and turn her resources to account.

The principle by which this ocean river works in its process of eliminating the lighter material, ultimately leaving behind on the shore the "blacksand" and its associated gold, is first to be considered.

The Nine Mile Beach, near Charleston, being a flat, sandy beach, is typical of the actual process of elimination of light material or concentration of beach gold and black-sand deposits that is effected by the sea, and can be studied better here than on most other beaches.

When once "blacksand" and gold shows in the ebb tide it is only a matter of a few days when it and any contained gold will be mainly found near high water-mark, which on this beach is about 1000 feet from low tide-mark.

It is a matter of great surprise to the casual visitor to learn that there is rarely gold in payable quantities at ebb tide-mark, and that it will not stay there, but gradually works up the beach.

PROCESS OF CONCENTRATION AT HIGH TIDE MARK.

When the ocean current has brought the golden dirt into the ebb every flowing tide takes the whole accumulation further up the beach, and in the process the sifting of the light from the heavy material is effected. Finally, only a residue of the very heaviest material is left behind, and naturally this, in proportion to the degree of elimination, is enriched in gold.

The process is explained thus: When a wave has spent its force, there is a moment of rest before it starts on its backward journey. During that period all the sand which the incoming wave dragged with it becomes stationary, the particles of higher specific gravity being covered by those of less specific gravity. The wave in receding, after the moment of inertia, does not gather sufficient momentum to disturb the heavier sand until a point is reached somewhat nearer the ebb than was the case when the wave was on its shoreward journey. So it is that each wave sweeping up the beach carries the golden sand to a point at which the receding wave has only sufficient power to "comb" off the lighter material. The process goes on, each incoming wave carrying the burden further in shore than the previous one, until finally a small, clean residue is found in its most concentrated form at the point where the receding waves have just sufficient power to drag back all but the material of highest specific gravity.

As the auriferous sand is being thus concentrated there is a movement northwards, so it is that where a promontory juts into the sea any given beach is richest at its southern end. On rare occasions a northerly wind may, on the open beach, reverse the order, and golden dirt be recarried southwards, but this is so rare that the general plan is not disturbed.

As regards the buried leads or those on the raised beaches of olden days the same rule holds good; the richest gold lies near where a headland has projected into the sea.

One does not travel far on the West Coast without coming to a river or a stream, and these to some extent modify the action of the sea, and owing to this action gold is found on a particular beach much further north than where the sea was left undisturbed in its work.

From the foregoing and a perusal of what the late Alexander McKay and other geologists have written on the subject, the reason seems clear why there are concentrations on the beaches of the heaviest materials which the rivers have brought to the sea.

Close observation extending over many years sustains the fact that the same forces as described were at work in days of long ago when those old raised beaches, now hundreds of feet above sea-level, and as far as eight miles inland, formed the beach upon which the waves broke, and on which, so to speak, the chaff was winnowed from the grain, and it is still happening on the beaches to-day. Geologically, all this is within our own time, but it is interesting to read the proof that the same ocean river in those far-back days kept dragging the lighter debris northwards; that in all the long intervening years no cataclysm of Nature has interfered with the old order; the prevailing winds then, as now, were from the south-west—the aeolian sands on these old beaches clearly show it.

THE RAISED BEACHES.

Mr Alexander McKay has dealt very fully with the subject years ago, but I would like to refer briefly to these old beaches. The oldest and consequently the highest of these old beaches, once at sea-level, is now 900 feet or so above it. Of this first sea beach only a few fragments are extant. These are scattered along the West Coast at various points, and were invariably rich in gold. This points to the fact that quite a large percentage of beach gold on the West Coast was cast up on this the oldest shore line of which we have any knowledge. It rested, for the most part, on a marine Tertiary formation, which was easily eroded by the creeks and rivers intersecting the old beach at right angles. The sea itself from the new shore line, after each uplift, in many places undercut the old beach, which, tumbling into the waves, had its gold contents redistributed along the shore. This process has been repeated with each subsequent uplift, of which there have been about twenty. The raised beaches, with their gold-bearing deposit being more or less destroyed, thereby assisting to enrich the deposit at the next lower level, which for the time being formed the ocean strand. Of course, the

highest levels suffered most, but all of those raised at all above sea-level have wide breaches in their continuity due to fluvatile erosion and sea encroachment. The last elevation which took place was an uplift of about 12 feet, the whole of the Coast apparently being subject to this movement from south of Hokitika to north of Westport. My observations have led me to the belief all the subsequent uplifts were regional

In my opinion it is evident that some of the deposits on these raised beaches were not deposited on the open beach, but were concentrated by the action of the $4\frac{1}{2}$ knot ocean current where the waves broke against a rock-bound shore. Addison's Flat (for the most part) was open beach, also Charleston, Brighton deposits, and Rochforts, nearer Greymouth are examples of the underwater concentration.

The open beach deposit is characterised by layers lying in conformity with the slope of the beach and feathering out to thin edges towards what has marked the ebb; the gold also is being concentrated in each superimposed layer of sand in the same manner as on the sea beach of to-day. The deposits not due to wave action, but the result of the slowly-moving ocean river have no tapering edges, but lie horizontally with the gold contents evenly distributed

Behind these deposits the land stands up boldly, but underneath the waves which beat against it the work was going on—the eternal winnowing of the light from the heavy material, these latter class of deposits though not of great extent, were the richest

GOLD STILL IN SITU

As there is much bold coast line along the present shore line, I believe from the history of the past that all the gold recovered from the beach deposits is but a fraction of that which is now lying along the unbroken bed of this ocean river extending from somewhere south of Hokitika to Cape Farewell, though when the deposit due to the Buller River has been passed the gold contents would gradually fade away. What evidence is there that practically all the gold which has been carried into the sea has not been cast up on the open beach? It is plain that the account

does not balance. It has been mentioned that there are wide breaches in the continuity of the deposits. Take the deposit on the Charleston Flat, for example; the valley of the Waitakere River is of far greater extent than the whole of the area of the remaining deposit. The leads of gold extend to the edge of the river bank on the south; on the north side they make again; in all the intervening space they have been eroded. To the southern edge of the river their richness was maintained; it continued again on the northern bank. It is safe to assume that the deposits washed into the sea were as rich as those untouched on either side of the breach made by the river. Where is that gold? Although the Nine Mile Beach immediately to the north of the estuary of the river has yielded considerable gold—not less than £500,000 worth—yet it is easy to demonstrate that very little, if any at all, is referable to the gold which the Waitakere washed off the Charleston field. Further south we come to the Brighton deposit. It was only due to the resistance of a granite mass sufficiently hard to withstand the hammering of the waves, which beat with unprotected violence against it, that any portion of that remained. Where the bottom was marine Tertiary sands the sea encroached upon the leads and left only some portion clinging along the back wall of the shore line, sufficient to prove that originally they had been of much greater extent. Where is this gold? It was brought down to the shore, which was then about 12 feet above the present one, but it was a steep beach on a hard, rock bottom, and not one ounce of that gold remained above water. It was dragged into the ocean river, where it remains. Just as the deposits with their gold contents vanished as they were brought to the sea, so afterwards, when the miner had won the gold from that portion of the deposit which remained, did his tailings vanish as they reached the sea. They were not cast on the shore. The beach, as stated, is not favourable.

Where is the 20-feet thick of blacksand which the miner sent down to the sea from the Brighton leads? In the bed of the ocean river covering up the maiden deposit which went ages ago from the neighbourhood.

The bed of this ocean river has been raised, and what was done in the past can be plainly observed, and that which this ocean current did in past ages it is doing to-day. When

one considers the vast areas that have been denuded of their deposits (carried to the sea), and considering the richness of the portions which remained, it is easy to see that the account, as stated, does not balance. The gold cast upon the present shore line is negligible when compared with the quantity brought within the influence of wave action, though it must be admitted that this conception is incapable of proof.

From these remarks and geological reports, more particularly the writings of the late Alexander McKay, it will be seen that the "blacksand" gold deposits of the West Coast are due to the ocean current to which it has been so often necessary to refer. Like a vast sluice box, this ocean river has never eased up for one moment in its work of concentration, the result being that only the materials of highest specific gravity were left behind, in this case mostly magnetite—the so-called "blacksand"—and gold.

Apart from the general or main body of blacksand, the matrix of which is not known, there are local deposits the source of which is apparent. Sometimes the two have become intermixed. A series of terraces immediately on the northern one-time estuary of the Buller River and about 200 feet above sea-level consist almost exclusively of this river's drift (with gold), though concentrated by wave action. Also all the gold found on the present beach northward of Westport is due to the Buller River. There is very little of the general body of blacksand along the coast from Westport until Karamoa is reached. Cape Foulwind probably diverts the ocean current too far out for the heavier material to be brought within wave action. The flood waters of the Buller River would also tend in the same direction. These two factors account for the almost total absence of the ordinary "blacksand" beach deposits adjacent to the Buller River.

Again at Fox's River there is a deposit of garnet sand both on the present beach and on a raised beach about 100 feet higher. The sample of gold on the present and the raised beach is that found in the river miles inland, together with its associated garnet sand. The amount of gold is but small, but both sand and gold have their origin in the Paparoa Range.

North of the Teremakau the Humphrey's Gully deposit, as eroded by the river, has been redistributed along the beach, intermixed with both gold and sand from other sources.

In the Barrytown district, with its rich coarse gold, though laid down by wave action, is clearly local in its origin. The gold was of too heavy a description to drift along with sand, many fair-sized nuggets being found in the deposit. This gold lead commenced immediately north of the estuary of Fagan's Creek, and undoubtedly was brought into contact with the sea at this spot, and was merely laid out and concentrated on the shore. In connection with this deposit what remains of it, like many other deposits, is only a small portion of the original, the lead being intercepted by a series of gullies. This gold never reached the ocean river. When it was swept from the gullies to the sea (wherever that point was) it was redistributed. As it is over a mile from the present shore to the coarse gold leads, it does not seem feasible that the shore line of those days was further seaward than the present one. Unless this happened to be the case it would seem almost impossible that any of Nature's forces removed this gold to any great distance from where it at one time formed part of the Barrytown deposit. In the Barrytown district there still remains a very large area of ordinary "blacksand" deposit, the aggregate gold contents of which may amount to a considerable sum, but the greater part is not amenable to a cheap recovery, that is, when compared with most beach formations, which are absolutely devoid of impedimenta

There is another kind of gold deposit on the West Coast which, though foreign to the purpose of this paper, I will refer to briefly. The Kumara field may be taken as typical of this latter. As regards the source of this gold geologists have propounded a theory, that whatever the matrix of the "blacksand" gold might be or wherever its geographical location this latter class was never in **situ** within the present boundaries of these islands. The evidence is certainly very strong in support of the theory that this gold was carried to where it now is by a large river which had its source somewhere away to west of the present coast line, when this Dominion formed part of a

much larger body of land, when it was part of a sunken continent. The nearest point now to the estuary of that ancient river is Blind Bay, Nelson, and the nearest point towards its source the Kumara field. Between these points the old river bed can be distinctly traced—over the Hope Saddle, via Reefton. Nowhere now on the land are the rocks *in situ* of which the bed of this ancient waterway were composed. The gold being now associated with the “wash” of this ancient river, the assumption is that it came from regions now beneath the Pacific. All that is certain is that there was such an ancient river, and the distribution of its gravels show that the flow was from Hokitika towards Blind Bay, but where its source or where its estuary cannot even be conjectured.

Before closing these notes upon the formation of these beach deposits, I submit the opinion that the greatest deposit of all forms the sea bed within the confines of that portion of the ocean current not subject to wave action. Can this hypothesis be proved, and if, as surmised, there is such a rich deposit, can it be recovered? The reply to this is that if subsequent to the last elevation of the land there was a subsidence of the coast line, then possibly the older and richer portion would be too deeply buried to even prove its existence, but the evidence is that there has never been a depression northward of the vicinity of Greymouth during the period of the elevation of the raised beaches, and, consequently, unless the water was much deeper originally than supposed, then the shore deposits which have been carried into the sea should not lie at any great depth. Their existence should be capable of proof. In any case gold which would be payable if on shore does, I feel confident, exist there, as a result of operations within a period long antecedent to the last uplifting of the land. As the surface lies from 30 to 60 feet beneath the water on an exposed coast line, I would consider that, no matter how great the quantity of gold deposited there is no economic importance; it is irrecoverable.

What now concerns us are those deposits which lie along the beaches of the coast at present sea-level, or, rather, slightly above it. In some places there is but a fringe of beach, or bays here and there along a rock-bound

shore. In other cases the beach (or what was once tidal area) is a mile or more in width. The accumulation of sand and shingle has gradually forced high water-mark back from its original position, the layers of sand and shingle in the intervening space being superimposed upon each other. There may be many leads or concentrations in this intervening space, each denoting the line of high water-mark for a considerable period. Between these concentrations the ground has been filled in more rapidly, and, not allowing for so much concentration, is poorer. Generally speaking, it all contains some gold. Usually, once away from the tidal area, the layers of gold-bearing "wash" carry an overburden of wind-blown sand. This may vary in thickness from a few feet to well on to a hundred feet, as in the case of the Nine Mile Beach.

It can safely be said that all, or almost all, the gold that can be payably worked without the aid of machinery has already been secured, but great as that amount is, I am of the opinion that there remains perhaps even more to be profitably won by the aid of suitable appliances.

Usually these beach leads were easily located, and as the bulk of the gold was above water level it was easily won

METHODS OF TREATING BEACH DEPOSITS

The first method employed for the tidal area was to wheel the sand from off the beach and wash it above high water-mark, water having been led to the spot for the purpose from small streams. In this way what might be termed the cream of the gold was skimmed off in very early times. Where water was not easily available by gravitation it was baled on to the dirt, which was shovelled into a "box" for the purpose. Though the recovery of the gold contents by these methods was very imperfect, yet a number of beaches yielded large quantities of gold.

The next step was an elongated "box" built in sections. This was carried on and off the beach with each tide, the water for washing purposes being led to the "box" by a light hose. This was a distinct improvement, enabling a greater quantity of dirt to be treated, and ground which would not have paid to wheel now gave good results. Later

the forepart of the frame of the "box" was fitted on wheels. This gave greater mobility to the plant, and it was only the work of a few minutes to run the box out 400 to 500 feet from high water and connect up the hose. With the incoming tide the work was carried on higher up the beach. The principal "beach combing" was on the Nine Mile Beach, near Charleston, the reason being largely that this beach was entirely free from shingle and grit, so that copper plates instead of plush could be used. A good recovery of gold was got no matter how fast the sand was fed into the box. This was not possible with plush; it would be choked with the same quantity of material and scarcely any of the gold saved at all.

Inland from the tidal area all along the coast the leads were "paddocked" down to water level, and the wash either wheeled or trucked to an elevation which permitted washing, the tailings as a rule being dumped back into the worked-out ground. In some cases water wheels and other primitive pumping appliances were installed and gold taken from below water level. This adjacent to the shore line is the mean height of the tide.

In a few years all the ground which could be payably "paddocked" was worked out, and, except for workings within the tidal area, the beach leads were deserted. Next, bucket dredges were tried, but only one was successful. This was a private dredge owned by Mr Joseph Taylor and operated just north of the estuary of the Grey River. This dredge, I believe, worked out all the available ground in that locality. The gold, though, was hardly the ordinary "blacksand" gold; it was clearly gold from the Grey River, and a heavier sample than the average. This fact probably accounts for this dredge proving payable, and is no criterion that other ground of similar value would pay by this method. The oscillation of a dredge on which the gold-saving appliances must necessarily be placed debars this kind of machine from being successful. Moreover, the dirt cannot be evenly distributed and fed to the tables with that regularity and even percentage of sand and water which the nature of the dirt demands. The specific gravity of the ironsand is so high and such a large proportion of the "wash" consists of this material that the conditions require to be very favourable for the separation of the gold from it.

At least two other bucket dredges were tried on "black-sand" deposits. The Leviathan, a few miles south of Greymouth, and another about 15 miles northward of Westport. The Leviathan got considerable gold, but was not a payable venture. The one in the Westport district certainly did not, but the machine was a poor one, and probably would have required unusual values in any case to avoid failure.

Near the site of the operations of this latter dredge a freak arrangement was set up. This might roughly be described as an endless rope to which scoops were attached, the idea being by this method to convey the material to a base where the gold-saving appliances were installed. Though it is stated that the dirt put through yielded 2s 6d per cubic yard, yet it did not pay.

On the Nine Mile Beach, on the beach near Hokitika, and at other places different kinds of suction pumps were tried, but these were more in the nature of models, or should have been so considered, though the owners were quite serious in the belief that they could effectively deal with the problem before them. All were quite ineffective and doomed to failure no matter how great the potentialities of the situation.

In 1896 the first hydraulic elevator was set up on the Barrytown beach. This was on quite a comprehensive scale, and continued operations successfully until the war period. About this time the head race, which was a very costly fluming of local timber gave out entirely. This wooden flume was the one mistake in this venture. With the decay of this flume, coupled with high costs in the war years, the fact that the pipe-line required extension and that a difficult zone of ground had been entered upon, all conspired to close this venture after about 20 years' life-time.

This elevating proposition was worked by three shifts, electric light being provided for night work, and, generally speaking, as a machine of its kind, fulfilled all requirements. The average value of the ground treated, I was informed by the manager, Mr McKay, was 1s 1d per cubic yard.

The great disability in connection with this venture, and it applies, of course, to all beach leads at sea-level, is the fact that in order to obtain sufficient "fall" to work by this method the elevator requires to be sunk to a great depth below the auriferous layers, these latter being not deep, in order to work the greatest possible area from a base. The large spread of gold-saving "tables" and other equipment in a concern of any magnitude involves a large outlay; it is therefore necessary that as much ground as possible be worked from each base. In this claim the area of a paddock was from 12 to 15 acres, and to obtain the requisite "fall" it was necessary to sink the elevator 35 feet to 40 feet beneath the gold values, through barren drift, beneath ocean level. The difficulties encountered in doing this have to be experienced to realise what it involved. It can be imagined what an enormous amount of material would drift into the sump aided by the large quantity of water with which it was charged, for the operation of sinking this elevator into position was going on in drift sand below sea-level. After being sunk to the required depth, a channel was carried forward, as the work proceeded, in the bottom of which was placed a wooden flume down which the material was carried by gravitation to the elevator, which lifted it 76 feet or so to the tables, where the gold was saved. The 76 feet of lift was made up thus: Depth below "wash," 40 feet; depth of "wash," including any overburden, 15 feet; height above surface of ground (in order to have "fall" for concentration purposes), 21 feet. Here a pressure of 600 feet or more was available, and a large body of water. These two factors alone made this a payable venture, but there were few places along the coast where this could be secured at a payable cost.

From the time the gold-saving tables were installed and a start made to sink the elevator 20 to 22 men were employed for a period of 10 months before it was sunk into position and the work of gold winning begun in earnest, and this was repeated with each shift to a new base. During this period not 10 per cent. of the debris dealt with was gold-bearing, the other 90 per cent. being drift below the "bottom." It is therefore evident that any machine which could supply the tables with sufficient dirt and feed it regularly to them, taking off the deposit only to the depth containing gold values, thus saving 10 months of "dead"

work, must have an enormous advantage. Moreover, in addition to the sinking of the elevator there was a great quantity of useless material shifted in making the various channels down which the dirt gravitated to the sump. The machine that did not require sinking into the "bottom" would avoid this also.

Two years later than the Barrytown undertaking an elevating proposition on a smaller scale was started on the Nine Mile Beach. The material to be operated upon was somewhat similar, though there was some impedimenta in the way of timber and stones at Barrytown which were entirely absent on the Nine Mile Beach, though the gold values per cubic yard were only about 4d pence as against, as stated, 1s 1d at Barrytown. The pressure available was 230 feet, and the quantity of water at the start of operations, and for years afterwards, not one-third that of Barrytown. The result was that it was found impossible to sink the elevator more than 6 feet below the "bottom," that is, the auriferous layers, the reason being that the quantity of water under the head available did not give sufficient power. It is evident that if the Barrytown elevator required a depth of 40 feet to bring within its scope an area of 15 acres, the area would be correspondingly less where only 6 feet of "fall" was available. This meant that the area being so circumscribed that could be dealt with from any base, the plant required shifting much more frequently than at Barrytown. There had been a fair margin of profit while actual working proceeded, but the "fall" having been used up and a shift to another base imminent it was evident that this profit would be more than absorbed before active operations could commence on a new paddock.

It was at this juncture that the writer, who was in charge of this concern, tried attaching a horizontally laid pipe from the mouthpiece of the elevator up to the "face." As nothing had been specially designed for this new addition to the hydraulic elevator, it was only considered experimental, but the result was an unqualified success. By the gravitation principle, each box 12 feet in length had absorbed $3\frac{1}{2}$ inches of fall, so that the boxes rose level with the bottom 240 feet, roughly, from the sump, the area worked being a little over an acre. By the aid of the extended suction pipe 10 acres of ground were worked from

that base, and the whole aspect of the venture changed. Later, further improvements were effected and hundreds of acres—all the available ground—on the Nine Mile Beach, between the years 1898 to 1922, were treated by this method.

GENERAL PARTICULARS OF OPERATIONS AT NINE MILE BEACH.

When the idea of using an extended suction pipe was adopted, as designed by the writer, more water was acquired and larger pipes installed, since the success of this system warranted increased expenditure. One phase of the operations is to carry the suction pipe out into the tidal area of the beach, where, when the sea is heavy and the rising tide has stopped sluicing operations, it is fed by the action of the waves, surely a unique performance and an utter impossibility in an open sluice box. When the tide recedes sluicing is resumed. The pipes used in this phase of the work have couplings and not bolted joints, and the mobility is such that two men can lay 200 to 300 feet of pipes in a few minutes, and likewise lift them again out of danger from the next incoming tide. This suction pipe has a radius of 15 chains or more as required.

The field of operations, apart from the tidal area, has been a strip of country adjoining the beach 147 chains in length by a width of from 7 to 10 chains, containing approximately 129 acres.

The material operated upon consists wholly of sand from 20 to 40 feet in thickness, except within the tidal area, where the gold-bearing material may be only two feet or so deep.

About 10 heads of water are employed under a pressure of 230 feet, of which $8\frac{1}{2}$ heads are used for power and $1\frac{1}{2}$ heads for sluicing. A large proportion of the material being below water level, the sand is consequently so charged with water that it almost runs into the pipe without sluicing, so that comparatively very little water is necessary at the face.

Gold saving is accomplished by running the material over a large spread of amalgamated copper plates, the area of these being 816 square feet, with a width of 102 feet

Work is carried on day and night with four men on the day shift and two men on each of the other shifts

The value of the ground does not vary much—the average is 3d per cubic yard. Within the tidal area the yield cannot be computed, but the yield per working hour is much the same as when working the deep deposit. In the tidal area the work is necessarily intermittent owing to the shifting of the plant.

Considering the low value of the material the success of the operations is entirely due to the system used. For the period March, 1913, to May, 1917, a total time of four years and two months, 15 acres were worked to an average depth of 23 feet. This contained roughly 1,670,000 cubic yards, and yielded gold valued at £20,648, or just approximately 3d per cubic yard. The expenses for the period were £6116, including diversion of 62 chains of County road costing £308, and an allowance of £5 per week for management. This works out at 7d per cubic yard. The actual wages time for winning this gold was 209 weeks, of which 163 weeks were occupied in sluicing. The remainder of the time was taken up in shifting the elevator three times, in repairing flood damage to the pipe line, and in shifting the county road.

The following are the returns received during the period under review —

	Weight			Value		
	ozs	dwt	grs	£	s	d
1913—						
April 18	118	15	4	412	4	0
• May 30	205	18	12	705	5	9
June 27	194	15	6	651	13	0
August 1	134	3	0	467	5	9
August 29	221	13	0	762	1	9
October 3	103	5	0	335	15	0
October 31	144	5	12	464	0	0
December 24	213	11	12	731	10	0
1914—						
February 28	94	0	0	320	7	6
February 27	131	12	0	390	0	0
May 8	94	14	0	324	0	0
July 10	120	13	0	389	0	0
September 30	4	18	16	22	0	0
November 17	158	2	0	566	17	1
1915—						
February 20	59	13	8	199	12	6
March 26	205	5	0	722	12	11
May 14	339	17	0	1,200	15	11
May 28	62	8	0	221	15	7
July 9	296	0	0	1 030	8	0
August 6	77	15	0	274	7	1
August 27	195	13	12	681	7	6
September 30	148	6	12	525	18	7
October 22	258	8	0	920	11	0
November 5	151	1	12	538	4	0
November 26	174	5	0	599	14	3
December 24	107	11	0	381	6	11
1916—						
February 19	12	0	12	38	13	8
March 18	94	0	0	334	17	6
April 26	281	0	0	1,000	0	0
May 17	160	0	12	560	0	0
June 23	—	—	—	868	7	5
July 14	—	—	—	468	7	5
August 1	—	—	—	520	0	0
August 23	—	—	—	399	16	9
November 11	—	—	—	636	9	6
December 1	—	—	—	450	0	0
December 23	—	—	—	233	10	6
1917—						
February 10	—	—	—	397	7	9
April 24	—	—	—	531	1	9
May 18	—	—	—	330	5	3
				£20,648 11 7		

Altogether in the 25 years of its history over £100 000 worth of gold was obtained, the average number of men employed being seven

Had it not been for the discovery of the extended suction pipe this would have been among the number of mining failures, for before it was tried it had been decided not to shift the plant to a new base, as it was certain that there was not sufficient gold to stand the expense.

Since then in several places in the Buller district the new style of elevator has worked ground impossible by any other method. It is true that it started in the old "face" at Barrytown, but operations were suspended after a time. This was due to factors quite apart from the merits of the plant or the value of the ground.

As stated, there are few places where under natural head sufficient power can be obtained to work these beach deposits, but I feel certain that a similar power-driven plant to the one I saw in operation in the Malay States, though applied differently, will yet profitably work thousands of acres of beach deposit on the West Coast.

There is an abundance of water available along the sea-board, though too costly, except in a few places, to bring from a sufficient altitude. Where wood and coal are comparatively cheap, or where electric power can be installed at a moderate cost, it is certain that the power-driven plant operating on lines similar to the suction elevator under natural head offers a means of profitably treating the remaining beach deposits of the West Coast, or so much of them as have values exceeding from 4d to 6d per cubic yard.

THE AURIFEROUS CONGLOMERATE OR CEMENT
DEPOSIT OF THE TUAPEKA DISTRICT, OTAGO,
NEW ZEALAND.

By WILLIAM R. SMYTH, Mine Manager, Lawrence.

The main purpose of this paper is to direct attention to the vast beds of auriferous conglomerate contained in a series of basins lying in a north-west to south-east line and extending from Blue Spur, at the head of the historic Gabriel's Gully, toward the sea coast at some point beyond Glenore.

The principal basins or localities in which this conglomerate exists are Blue Spur, Wetherstones, Forsyth, Waitahuna Gully, Adams Flat, and Glenore, and they are either contiguous to or situated at a short distance from the railway line—Milton to Lawrence.

For the purpose of this paper, the local name "cement" will be used, this being the term applied to it by the miners in the early days of gold-mining.

With a view to conveying some idea of the enormous quantities of material contained in these basins, the following figures and extracts taken from Dr P. Marshall's report on the Geology of the Tuapeka District will be of interest

Blue Spur.—Estimated total amount of cement originally present, 10,000,000 cubic yards, of which quantity over three-quarters has been treated or worked (It may here be stated that on account of the extensive operations carried out at Blue Spur, the structure and boundaries of the basin have been definitely ascertained, thus allowing of a reasonably accurate estimate being made.)

Wetherstones.—The estimated superficial area is two square miles, average thickness 200 feet, and the estimated total quantity of cement is 413,000,000 cubic yards

Waitahuna Gully.—Estimated quantity still remaining for treatment, 16,000,000 cubic yards.

Adams Flat.—This area measures a mile and a-half in extreme length by three-quarters of a mile in extreme width.

Forsyth.—As mining operations on this field of cement have not been of any magnitude, the boundaries of the deposits are not easily ascertainable, consequently no estimate of quantity can be made.

Glenore.—The area of cement in this basin is not actually known, as owing to its low-lying position the boundaries have not been defined. It is, however, believed to be of limited extent.

The composition of this material gives every appearance of its having been originally a river gravel, the pebbles being well water worn. It is singularly free from stones of more than nine inches in diameter, while boulders of 18 inches or more in diameter are rarely met with. The pebbles, etc., are firmly bound together by sand or fine-grained detritus, and the presence of some cementing medium has, speaking generally, caused it to set relatively hard, thus justifying the miners' term "cement," which has been applied to the whole deposit. A certain amount of pyrite exists throughout this mass of material, being more abundant at what is known as the "bottom" or lowest stratum, lying on the schist rock.

In the main the colouring of the cement is blue, but in many places the upper portion has been changed to red owing to oxidation of the compounds of iron.

The general body of cement is by no means of a uniform degree of hardness, but varies in a remarkable degree. This lack of uniform hardness does not depend upon the depth from the surface, but is in very large measure due to the induration and texture of the cementing medium, which varies in different places and in the different strata.

In some places a "fall" of cement when brought down will, in the process of falling, resolve itself into a loose

mass of shingle, while in others the falling, however forceful will fail to reduce it below the size of what might be called large blocks. Where these hard "areas" are met with, much explosive and manual labour are required to reduce the cement to such a condition as will admit of even a portion of its gold content being recovered by the usual alluvial system of treatment.

It seems now to be the accepted opinion of geologists and other observers that the original deposition of this body of material was fluvial or fluvio-glacial, the supposition being that the present cement originally formed the outfall gravel of some ancient river. It would seem that the earth's crust in this area had been subjected to some movement or buckling process, which had the effect of elevating the old river bed in some places and of depressing it in others, as the difference in the elevation of the cement surface amounts to hundreds of feet even in the same basin. In one place on the north-eastern margin of the Wetherstones basin there is a remarkable overthrust of the schist rock. It may here be stated that right throughout the cement area this schist rock forms the "bottom" or bed on which the cement lies.

Further, it is the accepted opinion that the large quantities of gold obtained from the gravel deposits in Munro's and Gabriel's Gullies, Wetherstones Flat, Waitahuna, etc., originally came from the cement that has been worn away and washed down from greater heights during the process of denudation in past ages.

It is not possible to calculate the quantity of cement that, by a process of natural erosion, contributed the large amount of gold won from the gullies and flats that lie within the control area of this old river-bed; neither is any accurate record available regarding the amount of gold won from that portion of the cement that has actually been worked and treated by man. It is probably within the bounds of reason to assume that the gold content of these vast bodies of cement that yet await development and treatment is much greater in quantity than the amount actually won from the alluvial gravels and cement deposits of this locality during the years that have elapsed since their discovery by Gabriel Read in the year 1861.

The most important feature of these deposits or basins of cement is that they all carry gold. Besides this, the

precious metal is found throughout the whole mass, from the surface to the rock-bottom. There is, however, no uniformity or evenness of distribution of gold, as the richness varies considerably in the different strata. As a rule, the richest stratum is the one lying on the rock-bottom. But even on this rock-bottom the gold is not evenly distributed, as here and there runs or leads occur which carry gold in much greater quantities than is contained in the adjacent or surrounding parts of the deposit.

The Blue Spur field is the one on which the most extensive operations have been carried on. In fact, the scale of operations has been so considerable that to those intimately acquainted with its history this cement basin presents itself as an open book.

A thoroughly reliable estimate places the value of the poorest of the Blue Spur cement at not less than 8d per cubic yard. Much of it has given a return of several shillings per cubic yard, while the leads or runs have in many cases contained gold to the value of several pounds per cubic yard.

As has already been stated in this paper, Dr Marshall in his report—published in 1918—estimated the original quantity of cement in this basin at 10,000,000 cubic yards, and he further estimated that of this quantity more than three-quarters had been treated. The amount now actually remaining for treatment will be reduced somewhat below one-quarter owing to the fact that operations since then have been carried on continuously by the Gabriel's Gully Company and the Lawrence Sluicing Company.

Incidentally it may be mentioned that these two companies have quite recently agreed to combine forces for the purpose of carrying on operations conjointly in regard to the working of a certain portion of the deposit that lies along and adjacent to the line of demarcation of their respective mining areas.

Wetherstones basin contains much the largest separate body of cement of all, and although operations have been carried on for many years it may be said that not more than the fringe has as yet been touched. The vast quantity of 413,000,000 cubic yards is estimated to be contained in this basin, and its gold content per cubic yard is probably

not much, if any, less than that of the Blue Spur deposit. The depth of this deposit and the lack of an unlimited supply of water have probably militated against the carrying on of more extensive operations in this locality. Its depth below the lowest surface level has also been the main factor in the retardation of exploratory work for the discovery of the rich runs or leads which may exist. The potential richness of this field therefore remains almost untouched; and it is interesting to reflect on what may be the total value of the gold content of this enormous mass. In this connection and for purposes of comparison Dr Marshall's report may be again quoted. On page 59 thereof appears the following:—"It is estimated that gold to the value of £5,000,000 has been obtained from the two areas of cement at Blue Spur and Wetherstones, together with their alluvia in the adjacent gullies. This, however, is not more than a guess."

Those most intimately acquainted with the life history of the field do not, however, regard this as other than a conservative estimate or guess. In regard to the Wetherstones basin, it is within the knowledge of the writer (the writer having been long associated with the management of the Golden Crescent Company, which operates on this field) that the value of the gold content of the whole of the cement operated upon has averaged approximately one shilling per cubic yard. If, however, an average of sixpence per yard be taken, it will be seen that the estimate of the gold content of this 413,000,000 cubic yards exceeds £10,000,000, and in the writer's opinion this is a very low estimate.

Forsyth cum Paddy's Point Basin.—No work of any great extent has been carried out here, although good returns are said to have been obtained by individual miners in the early days. This dormancy is probably to be accounted for by the fact that almost all the available water is being used at Blue Spur, Wetherstones, and Waitahuna.

In the Waitahuna basin a considerable area of the cement has been operated upon, and extensive operations are still being carried on by the Sailors' Gully Goldmining Company. The same variations in strata, density, or hardness of material, degree of richness, etc., are observable in this basin as at Blue Spur and Wetherstones.

Adams Flat.—Owing to lack of sufficient water, operations in the cement deposit here have been confined to a limited amount of sinking and tunnelling, the material raised to the surface being treated by that small, though useful, primitive appliance known as the "cradle." That the material treated in this fashion gave a return that justified the carrying on of operations over a lengthy period is quite sufficient to give some indication of the value of its gold content

Glenore Basin.—The deposit in this basin being below water-level, practically no work has been done here. The over-lying alluvial gravels were, however, partly worked in the early days, and subsequently a much greater area was operated upon by dredging. On one occasion when an opportunity occurred through the pumping out of a dredging paddock, the underlying cement was tested in a small way. The writer has been assured by a member of the dredging party who carried out this test that the prospects obtained were good

TREATMENT OF THE CEMENT.

Since the days of 1861 there have been many steps or gradual changes leading up to the present method of treating the cement for the extraction of its gold. After discarding the early primitive appliances, the method generally employed was the stamper battery or crushing-mill. By this means operations were carried on at Blue Spur, Wetherstones, and Waitahuna. Blue Spur, mainly on account of its favourable situation—i.e., its elevation, which afforded comparatively easy means of access to its lower strata, became the centre of greatest activity. By the regular methods of tunnelling, hauling, etc., the greater part of the lower strata was removed. Its richness is indicated by the fact that in many cases handsome returns were obtained from the treatment of the material in a stamper battery of light pattern and low capacity.

Subsequently much of the surface cement situated in an elevated position was ground sluiced. In the performance of this operation the cement was first shaken by heavy charges of blasting powder, then further reduced by the

The Lawrence Company, operating at Blue Spur, and Sailors' Gully Company, operating at Waitahuna, took similar steps to obtain greater pressure by the extension of their pipe-lines, with equally beneficial results.

This last method of treatment by water under high pressure represents the best achievement and the most advanced point yet reached in the way of dealing with the cement in the mass for the extraction of its gold content.

In all cases where the material is not of too great hardness or tenacity the water can be made to deal with it at a reasonably rapid rate, the pulverising power of the water being effective and economical. At times, however, certain strata are met with which almost defy the breaking and bursting power of this terrific force of water, and though these strata may not exhibit complete defiance, they yield so slowly as to render the effort of the water for the time being almost valueless.

It will thus be realised that water power "per se" has not proved its complete effectiveness in the treatment of the cement. Besides, it suffers from a disadvantage in that when the cement being operated upon presents a face 80 feet or more in height the nozzle, for reasons of safety, must be kept at such a distance from the face that the cutting power of the water is considerably reduced before it reaches its objective. Another disadvantageous factor in connection with the direct application of water is wind, which, when blowing strongly, seriously affects the force of the water between the nozzle tip and the object against which it is directed. Occasionally the entire stream from the jet is blown away in spray, and the position of the operator is rendered distinctly uncomfortable.

These points are mentioned in order to indicate the extent of disadvantages and loss of power, which, however, may be greatly minimised or entirely eliminated by the introduction of some more effective method.

By the system at present in use any material which will yield readily to the action of water under high pressure can be effectively treated at a cost of less than twopence per cubic yard, but in the case of the harder areas of cement the extra time and energy required to be expended in order

to reduce it to such a state as will allow of the recovery of the gold, causes a considerable increase in the cost of treatment.

Dislodging and pulverising of the cement at a rapid and a not too expensive rate is the problem calling for solution. All further essential treatment can be carried out at a cost of probably not more than one penny per yard.

WATER POWER AVAILABLE.

A rough calculation of the quantity of water available — the respective cement basins and the potential power derivable therefrom is as follows:—

Blue Spur.—The total length of open water-races inclusive of flumings, etc., which have been constructed and are used for the conveyance of water to this field is about 200 miles.

Most of this water is conveyed, at a high altitude, from the upper reaches of the Waipori River. From this source, under normal weather conditions, about 30 sluice heads are obtained, while about 12 heads are brought on to the field at a somewhat lower elevation from another source.

This quantity of water, under the pressure obtainable by some alteration to the existing pipe-line and some small extension of their length, is capable of developing energy to the extent of 3000 horse-power.

Wetherstones.—The water that commands this field comprises about 16 heads, and is capable of developing energy to the extent of 1000 horse-power. About half of this water is also conveyed from a tributary of the Waipori River, the race being constructed at a high altitude above the cement deposit. Incidentally it may be mentioned that the greater part of the water utilised in the Blue Spur basin can readily be diverted to the Wetherstones field.

Waitahuna.—On this basin the quantity of water available in respect of which races have been constructed is about 22 heads. Much of this water drops into the pressure pipes at a high elevation, and its capacity for energy production is about 800 horse-power.

Adams Flat and Glenore.—No water-race of any magnitude or value has been constructed on to these fields, and now there is no unsecured water available at any reasonable elevation

Some of the water at present in use on the Waitahuna field could, however, be conveyed to either of these basins by an extension of the open race, at an elevation sufficiently high to admit of considerable power being developed

GENERAL

In concluding this paper the writer wishes to state that, in the writing of it, his intention has been to convey in as concise and lucid a manner as possible some idea of this remarkable deposit of conglomerate, whose yield of gold has probably equalled, if it has not excelled, that of any other auriferous deposit in the South Island; and, further to furnish some information regarding the nature and scope of the gold-winning operations that have been carried on up to the present time

Regarding the economic value of the cement, it may be stated that where estimates have been quoted it is the considered opinion of those deemed competent to judge that such estimates err on the side of moderation

The outstanding fact is this, that a vast amount of material containing gold of an estimated value of many millions sterling lies there waiting and inviting treatment by the vigorous application of some up-to-date method for the extraction of its wealth

More than 80 per cent of this material lies in the basins or fields where water power is available at little more than nominal cost, and the water is in such abundance as to eliminate entirely the problem of power supply

In all probability there are already in existence mechanical contrivances capable of breaking down, crushing, and, where necessary, of lifting the material to any required height, which contrivances if harnessed to and operated by just a fraction of the energy that the water power is capable of developing would so revolutionise the working of this vast deposit as to make all former methods of treating it look trivial and inadequate.

The alternative to treating these deposits in the mass would be to have them thoroughly and systematically bored for the purpose of locating the rich runs or leads. When located the underground method of working could be resorted to. Latter-day appliances would be brought into operation, and these, used in conjunction with the power available, should produce larger returns than those obtained by the old-time stamper battery when underground work was carried on by pick and shovel and the slow-going hand-drill; when also the stamps were light compared to those now used, and their capacity relatively small.

In the past, no doubt, the greater part of the gold content was recovered from that portion of the cement treated by the stamper battery, but in regard to the hard strata treated by other methods in the early days, and even in the case of the hardest strata now being treated by water under high pressure, a large percentage of the gold was lost. This has been amply demonstrated by the fact that in Munro's and Gabriel's Gullies great quantities of the tailings have been worked a second, and in some cases even a third, time with highly satisfactory results.

It will thus be seen that everything points to these cement deposits as offering scope and opportunity for the remunerative investment of capital to develop what are undoubtedly the largest alluvial mining propositions at present known in Otago. In the event of their development being undertaken in some wholesale manner, it seems not unjustifiable to expect the financial results to rival the rich returns obtained in the Tuapeka district in the golden days that followed the historical discovery of Gabriel Read.

BOILER WATER: ITS COMPOSITION, EFFECTS DURING USE, AND ITS TREATMENT.

By D. B. WATERS, Otago University.

SOURCES OF BOILER WATERS.

Boiler water is obtained from such sources as streams, rivers, lakes, springs, shallow wells, deep wells, and mines.

The original source of such water is that which is poured down upon the earth's surface in the form of dew, mist, rain, hail, and snow. Such water is not used when it falls, but is in contact with the rocks forming the earth for a short or long period ere it is used for boiler purposes.

The result of such contact is that the water so used is ver pure water.

PURE WATER.

Water consists of the combination of two elementary gases, oxygen and hydrogen, forming a liquid at ordinary temperatures. Pure water is a chemical substance, which has the property of absorbing and dissolving many other substances, liquids, solids, and gases. Water not only dissolves other substances, but it forms intimate mixtures and also chemical combinations.

The power water has of absorbing and dissolving other bodies varies with its temperature. Thus hot water may dissolve a substance much more readily than cold water, and likewise dissolve more of it. Conversely cold water may be a more vigorous dissolving agent of some substances than hot water is.

Water also has the property of forming an intimate mixture with fine particles of solids, and retaining these, if very fine, in suspension for a long time, especially if the water is in motion.

Since water absorbs gases, rain water as it falls through the atmosphere becomes charged with the gases composing atmospheric air, oxygen, nitrogen, and carbonic acid. Hence rain water as it reaches the earth is not pure water, but is a solution of those active gaseous bodies oxygen and carbonic acid—a weak solution, but still an active one.

NATURAL WATERS.

All kinds of water such as rain water, river water, spring water, well water, mine water, or water from any source form “natural waters” as opposed to pure water, this latter being obtained from some form of natural water by distillation and subsequent extraction of any gases contained in it.

CONTENTS OF NATURAL WATERS.

Considering ordinary natural waters obtained from the sources mentioned, the contents of any sample may consist of the following groups of constituents:—

1. Solid matter, as clayey matter, soot, etc., held in suspension.
2. Solid matter held in solution or in chemical combination, as bi-carbonates of lime and magnesia, sulphates, nitrates, etc.
3. Gases absorbed as oxygen, carbonic acid, ammonia vapours, etc.

COMPOSITION OF NATURAL WATERS.

Solid Matter in Suspension.

Running water carries solids in suspension, the more turbulent it is the greater is its carrying power. Water running over a clay bed will carry more such matter than when the bed is hard rock. Rain water in certain localities may contain quite a lot of soot and also dust washed out of the atmosphere.

Certain of such suspended matter is readily settled out of water on standing, but water may contain solid matter in a colloidal state, an extremely fine state of subdivision. Such matter is extremely difficult to settle or filter out.

When boiled, however, a coagulation of particles will occur, and, in a boiler, produce sediment. The composition of this solid matter in the colloidal state is mainly silicates of aluminium, or of the alkalis soda and potash.

Solid Matter in Solution or Chemical Combination.

Rain water absorbs oxygen and carbonic acid wherever it falls. In the vicinity of industrial works and large towns it also will absorb, according to circumstances, ammonia vapours and the gases produced from the burning or oxidation of sulphur and arsenic compounds. The effects of these last substances is, however, only local, but the effects produced by absorbed oxygen and carbonic acid are universal.

It is not necessary to enter into the action of rain water charged with these gases as it runs over the earth's surface or through underground passages, that is a geochemical study. It will suffice to say that natural rain water being a chemical liquid substance, with strong dissolving powers, during its short or long contact with the rocks of the earth dissolves a variety of substances, the amount dissolved and taken into solution depending upon the class of rock and the time of contact.

The chief chemical bodies dissolved are the following:

Table No. 1

Silica partly as such, but mainly as soluble silicates.

Bi-carbonates of lime and of magnesia.

Carbonate of soda.

Sulphates of lime, of magnesia, and of soda.

Calcium chloride, magnesium chloride, sodium chloride.

Nitrates of lime, of magnesia, and of soda

Also soluble compounds of alumina, oxides of iron, and oxides of manganese

Organic matter as such, or as organic acids.

It is very difficult to know in what combinations the various constituents of water exist, so it is perhaps better to state that water contains the following, and in analysing water the various constituents are determined in this way:

Table No. 2.

(Ultimate composition of water.)

Silica, sulphur tri-oxide, carbonic acid.

Lime, magnesia.

Sodium oxide, potassium oxide.

Alumina, Ferrous oxide, oxide of manganese.

HARD AND SOFT WATERS.

A hard water is popularly defined as one with which it is difficult to obtain a lather when it is shaken up with soap, whereas a soft water is one which readily gives a lather.

More strictly defined, hardness is that property imparted to water by the presence of such substances as the carbonates of lime and magnesia, also the sulphates of these substances. Chlorides and nitrates of lime and magnesia also assist in rendering water hard, but they are not of so much importance or are nearly so common as the carbonates and sulphates.

The principle of the 'soap' test is based on the fact that soap contains oleate of soda, which, when shaken up with water, reacts to form a lather. When water contains a lime or magnesia salt, insoluble oleate of lime or magnesia is formed; this falls as a precipitate, and no lather is formed. This continues so long as any lime or magnesia remains to be precipitated. When all such compounds of lime and magnesia are converted into oleates, then further additions of soap solution give a lather. Hence with any sample of water the amount of soap solution required to give a lather is a measure of its hardness

A water which requires only a very little soap to give a lather is termed a "soft" water, or is one which is free, or nearly so, of soluble salts of lime and magnesia. On the other hand, a water which requires an appreciable amount of soap to give a lather is termed a "hard" water, and the conclusion is that it contains salts of lime and magnesia.

TOTAL, TEMPORARY, AND PERMANENT HARDNESS OF WATER.**Temporary Hardness.**

This is the hardness of water which is due to the presence of carbonates of lime and magnesia, held in solution by carbonic acid, and therefore existing as soluble bi-carbonates. When water containing these bi-carbonates is boiled the carbonic acid is expelled, carbonates of lime and magnesia are formed, and these being insoluble in water are precipitated as a white powder. Bi-carbonates of lime and magnesia cause "temporary" hardness, since on boiling these are precipitated and can be filtered off, giving water free from hardness due to their action when in solution.

Temporary hardness of water is therefore that kind of hardness which can be removed by boiling the water.

Permanent Hardness.

This is the hardness of water due to the presence of sulphates of lime and magnesia in solution, also the chlorides and nitrates of these and other salts in solution. Hardness due to these substances cannot be removed by boiling the water.

Total Hardness.

This is the sum of the temporary and permanent hardness.

The determination of the respective amounts of temporary and permanent hardness is therefore a guide to some extent of the composition of a sample of water.

INTERPRETATION OF HARDNESS TEST.

The use of the soap test, by which the hardness of water is determined, and its relation to the general composition can be interpreted as follows:—

1. If a permanent lather is obtained on the addition of five drops of soap solution, and, after vigorous shaking, remains permanent for five minutes, then the water can be classed as a "soft" water, and, further, it can be concluded that it is not likely to form a "scale" in the boiler.

2. If a sample of water requires more than five drops of soap solution to form a permanent lather, then the water can be classed as a "hard" water, the degree of hardness depending upon the amount of soap solution required.

3. In the case of a hard water, if it is found that the temporary hardness is high compared to the permanent hardness, then it can be concluded that the hardness of the water is mainly due to carbonates of lime and magnesia. This means that the water will be scale-forming in a boiler, but that the scale will be comparatively a soft one.

4. If the hardness is found to be due mainly to permanent hardness, then it can be concluded that the water contains probably mainly sulphate of lime, etc., and in such a case the scale formed will be a hard scale.

Permanent hardness may be due to chlorides and nitrates, in which case the water would be corrosive rather than scale-forming.

5. If the water contains both temporary and permanent hardnesses then a hard scale will form.

The remarks on scale formation and corrosion are anticipating what is more fully considered later on.

Gases Absorbed by Water.

In boiler waters obtained from the sources mentioned, the only gases that such waters will contain are oxygen and nitrogen (from atmospheric air) and carbonic acid.

Rain water as stated absorbs oxygen and nitrogen from the atmosphere, but not in the proportions that these gases exist in the atmosphere. Atmospheric air contains by volume in round numbers 79 per cent. of nitrogen and 21 per cent. of oxygen. In water, however, the respective amounts of these are nitrogen 65 per cent. and oxygen 35 per cent. Of these two gases nitrogen is inert, oxygen being the active agent. In water, therefore, the relative amount of oxygen being increased, its activity is greater than in the atmosphere. Oxygen under certain circumstances is a corrosive agent in a boiler.

Carbonic acid dissolved from the atmosphere by rain water is a very active agent in water, especially in that which passes through underground passages, assisting the

water to dissolve rock constituents. Water is found also to absorb more carbonic acid from the earth's crust. It is this carbonic acid which holds carbonates of lime and magnesia in solution.

The gases contained in water are given off when it is boiled as in a boiler.

CHEMICAL CHANGES OCCURRING IN STEAM BOILERS

Any boiler water can be looked upon as a chemical solution containing any or all or any combination of the constituents mentioned. Since in a boiler high temperatures are employed, and, further, the water is becoming concentrated owing to the evaporation of steam chemical changes take place which would never occur in cold water. The changes that occur can be tabulated as follows:—

1. Matter in suspension, especially colloidal matter is caused to coagulate, and then has a better chance of becoming entangled in any other precipitating matter, and may thus be found in the scale. Suspension matter has no chemical action.

2. Precipitation of certain of the solid bodies held in solution either with or without decomposition.

Other soluble constituents remain in solution, but become more and more concentrated and therefore may become more active.

4. Interactions between the soluble constituents.

5. Elimination of gases with the steam.

GENERAL EFFECTS PRODUCED BY CHEMICAL CHANGES

1. Production of "sludge," forming a loose deposit.
2. Production of "scale" or an incrustation, which adheres to the boiler shell or tubes, and is more or less hard.
3. Corrosion of the boiler shell, tubes, and steam pipes.
4. Priming.

These two points, chemical changes and effects produced, must be considered together, the latter being caused by the former.

EFFECTS OF STEAMING ON BOILER WATER CONSTITUENTS.

Matter in Suspension.

Since all easily settled or filtered matter should be removed from water before it is used, it is only necessary to consider the colloidal matter. This as stated becomes coagulated, and will form sludge. Some may become entangled in scale-forming matter and therefore enter the scale.

Substances in Solution.

1. Silica.—This as such is only soluble in water to a small extent, but it also occurs as the more soluble hydrate of silica, also as soluble silicates of alumina, iron oxide, and sodium silicate. In whatever form it exists the tendency is for silica to be precipitated as such or as a silicate. By itself it would form sludge, but in the presence of scale-forming ingredients it becomes entangled, and some of it enters the scale. Silica is not an active body in boiler water, not in itself causing trouble.

2. Compounds of Alumina, Iron, and Manganese.—Compounds of these only exist to a small extent in most boiler waters, but are generally present. Alumina in the form of hydrate or as sulphate is more common than the others. Iron compounds are ferrous hydrate, bi-carbonate, and sulphate, and so also for manganese.

In whatever form they exist the tendency is for them all to be precipitated and form sludge, but the precipitated oxides also will be found in the scale owing to entanglement.

3. Bi-carbonate of Lime.—This, on being heated, loses carbonic acid, insoluble carbonate of lime being formed. This carbonate settles out forming partly sludge and partly scale.

4. Bi-carbonate of Magnesia.—This also loses carbonic acid, and carbonate of magnesia forms. This carbonate is further changed into magnesium hydrate, giving off more carbonic acid.

In cases where the boiler pressure is high this hydrate is decomposed into magnesia oxide. This oxide is very light, and tends to rise to the surface of the water, and may cause foaming.

Magnesia also deposits on the boiler, and may give the appearance of aluminium paint. Magnesia is a constituent of many boiler scales if its salts are present in the water through entanglement

Note—It will be remembered that the two foregoing substances are the cause of temporary hardness in water, and thus the effect of temporary hardness constituents is to produce scale-forming substances, bi-carbonate of lime producing carbonate of lime and bi carbonate of magnesia mainly oxide of magnesia, since boiler pressures are mostly high enough to do this.

5 Carbonate of Soda—This is a very soluble salt, and remains in solution. At pressures greater than 100lb carbonate of soda will form caustic soda, when other actions take place, that need not be considered

6 Sulphate of Lime. When in solution in cold water this is in the form of the hydrated sulphate, but when the temperature rises to 100 degrees Fahrenheit the power of water to hold it in solution becomes reduced, and at a temperature of 260 degrees Fahrenheit (equivalent to a boiler pressure of only 20lb per square inch, as per gauge) the hydrated sulphate is decomposed, and insoluble calcium sulphate formed. This substance forms scale only, and is the worst constituent that can be formed in a boiler.

Note—It may be noted that carbonate of lime and sulphate of lime are both deposited by chemical decomposition, heat being the cause in each case. Carbonate was precipitated because its solvent carbonic acid was expelled, and sulphate because the temperature of the water compelled it to part with its water of hydration

7 Sulphate of Magnesia.—This is very soluble both in hot and cold water, and does not directly take part in any way. Indirectly it does, since it reacts with calcium carbonate forming calcium sulphate and magnesium carbonate, and these then act as shown as scale-forming substances. It is thus possible for a boiler to have a calcium sulphate scale when the water does not contain any calcium sulphate in solution

Another indirect action is by a reaction between magnesium sulphate and sodium chloride forming magnesium

chloride and sodium sulphate. The former of these is a very corrosive substance.

Indirectly, then, magnesium sulphate may be a very active deleterious substance.

8. Sulphate of Sodium.—A very soluble salt, but more soluble in cold than in hot water. If it becomes concentrated in boiler water it will crystallise out during steaming, the scale can, however, be washed out from the boiler by cold water.

9. Nitrate of Lime.—Also a very soluble salt, having no effect itself. Under high pressure it is changed into lime, which ultimately deposits, and nitrite of lime, which has a corrosive action on iron.

10. Nitrate of Magnesium.—A very soluble salt, acting indirectly by attacking carbonate of lime and forming nitrate of lime and magnesium carbonate; these then react as before.

11. Nitrate of Sodium.—A very soluble salt, more soluble in hot than in cold water.

12. Calcium Chloride.—This is not a constituent of natural waters, but is present in boiler water when steaming if the water contains both carbonate of lime and magnesium chloride. It has a corrosive action.

13. Magnesium Chloride.—A very soluble salt, found especially in natural waters which may be contaminated with sea water. When in dilute solution, as in water, it has a very corrosive action upon iron, forming ferrous oxide, which remains insoluble. The action seems to be catalytic. Magnesium chloride is the chief corrosive substance that may occur in boiler waters.

14. Sodium Chloride—Very soluble, and has no direct action, but reacts with sulphate of magnesium to form magnesium chloride, which, as shown, is corrosive.

GASES CONTAINED IN BOILER WATERS.

1. Oxygen.—When water is boiled this is given off. This gas has a great affinity for iron, forming oxide of iron. Hence oxygen is a corrosive agent, attacking the shell and tubes of boilers. The greater the amount of absorbed oxygen the greater the corrosive action. This

effect is especially noticeable in the case of boilers working in conjunction with condensing engines, when during the circulation of the water from the engine through condenser, extraction pump, feed reservoir, and feed pump this hot water picks up much air and therefore more oxygen, making the water active corrosively. Means are now taken to prevent this absorption of air in condensing plants by degassing.

2. Carbonic Acid.—This gas is also given off when water is boiled. There is much controversy as to whether this gas is corrosive or not. Probably its action is to convert iron oxide, formed by the corrosive action of oxygen, into soluble carbonate of iron. This, then, allows the oxygen to act on more iron of the boiler, and thus the corrosive action is increased.

ACID AND ALKALINE WATERS.

Certain samples of water are found to contain free acids, especially sulphuric. This acidity is to be looked for in streams or other sources of water which pass certain classes of industrial works, as gas works, coke-making plants, and especially water from mines or water from slack and waste heaps at mines whether on fire or not, if such contain sulphur compounds. Water draining from coal mines on fire is mostly of an acid nature.

All acid water is bad for boiler feed purposes. Though water is not acid in its natural form, it may yet become so when boiled in a steam boiler. This is the case especially if it contains sulphates of alumina, iron, or manganese. These are decomposed, forming insoluble oxides and sulphuric acid. So also certain nitrates and chlorides will be decomposed, giving nitric acid and hydrochloric acid. These acids attack and corrode iron.

When waters are naturally alkaline this may be due to different causes, the most deleterious alkaline substance being carbonate of soda if present in too large an amount. This carbonate of soda is also introduced into water during most "treatment" processes, but if its amount is kept down by blowing off it will not have a bad effect. On the other hand if it becomes concentrated, and more especially if under high pressure, it is decomposed into caustic soda and other products, which cause trouble in a boiler.

OIL IN FEED WATER.

Especially in condensing steam plants there is always a danger that the returned water will contain some lubricating oil. This oil may be a pure mineral oil, or may be a compounded oil, that is, an oil containing both mineral and vegetable or animal oils. These latter oils contain fatty acids which cause corrosion, whilst mineral oils do not except under certain rare conditions. Oil introduced into a boiler will, however, cause scale. This is due to the fact that the fine particles of oil coagulate and become entangled with any solid matter in suspension. Such a mass will settle on the shell in small patches, and is a bad form of scale, since it is a poor conductor of heat, and therefore causes overheating of the shell or tube, causing these to be oxidised or, as more commonly termed, burnt. This causes weakness of the plate or tube at that spot.

GENERAL CONCLUSIONS RE CONSTITUENTS OF NATURAL WATERS.

The effects of heating natural waters in a steaming boiler have, from a chemical standpoint, been only touched upon, but the object aimed at, in giving even so much, has been to bring before users the fact that natural waters may be very complex in composition, and that in a boiler steaming under high pressures the chemical reactions are more or less complex and active according to the composition of the water. Further, that the effects produced may be very deleterious to the boiler itself, and also reduce its steaming rate except an excess of fuel is employed.

SLUDGE, SCALE, CORROSION, AND PRIMING.

These are the effects produced in a boiler during steaming, varying according to the composition of the water.

1. Sludge.—This is mainly due to matter in suspension as clayey matter. Such should only be obtained from colloidal matter, since all coarser material of this nature should be removed by filtration. Sludge may also contain carbonate of lime, silica, magnesia, and oxides of iron, alumina, and manganese.

2. Scale or Incrustation.—The chief scale-forming ingredients in water are carbonate of lime and sulphate of lime. Carbonate of lime forms a white and comparatively soft scale by itself, and can therefore be fairly readily chipped off. Calcium sulphate forms a hard, white, firmly-adhering scale, difficult to remove. The carbonate of lime scale is porous, whilst that of sulphate of lime is non-porous. This means that a sulphate scale is a worse conductor of heat than a carbonate of lime scale, and requires more fuel to generate steam.

Boiler scales, however, are found to consist of both carbonate and sulphate of lime, and by entanglement contain also clayey matter, silica, magnesia, and oxides of iron, alumina, and manganese, all picked up from the sludge held in suspension during steaming. The scales produced in this way are all insoluble scales that can only be removed by chipping.

Another form of scale is one composed mainly of oxide of iron or an iron rust scale. This scale is produced by the corroding action of oxygen, carbonic acid, etc., in the water.

A scale removed from a boiler will often be noticed to consist of a layer of iron rust next to the shell or tube, often quite thin, then a thicker layer of light-coloured scale. The explanation is that corrosion started on the clean boiler surface, but scale-forming ingredients also were formed, and these soon covered the corrosion scale of iron rust and stopped that action.

Another form of scale is that due to soluble salts, such as sulphate of soda, being forced out of solution due to concentration of the liquid. Such scales are dangerous, but when the boiler is emptied such a scale can be washed off with cold water.

Another but rarer scale is that due to silicates in the water. These also give a hard scale, having a bad effect on the shell. Such soluble silicates as those of lime and magnesia do not occur naturally in boiler water, but when lime and soda are used for treatment purposes and the quantities are not well controlled there is a danger that these soluble silicates will be formed.

Scale due to grease or oil in the feed water has already been mentioned.

There is no definite composition of boiler scale. The composition varies much, depending upon the composition of the feed and water and also at times the substances used to "treat" the water

3. Corrosion —Corrosion of a boiler shell and tubes is shown by roughening of the shell in places, by pitting, and by the growth of little pinnacles of iron rust. These latter are bad, since inside the pinnacle there is still an action going on eating into the plate. The action of corrosion is, as before indicated, due to the presence of dissolved oxygen and carbolic acid in the feed water. Oxygen is probably the main corroding agent, and the more a feed water contains the greater the effect. Corrosion is also due to the action of acids either in the feed water or formed in the boiler.

The whole effects due to corrosion are not brought about by direct action of the feed water, but may be due to the composition of the metal forming the boiler shell and tubes. Sometimes a boiler is found to pit or corrode only in one or two spots, whilst the rest is immune. This result is almost certainly due to that portion of the plate being of different composition to the rest of the plates or tubes; there is a want of uniformity in the composition of the metal.

4 Priming —This is the phenomena of water coming over through the steam piping with the steam. There are two forms, known as foaming and bumping respectively.

Foaming is that form in which the water comes over as a froth, whereas bumping occurs when the water is thrown up in masses intermittently, and some of it enters the steam pipe.

Foaming is due in the first place to the presence of an excessive amount of fine matter in suspension, as for instance oxide of magnesia. A small amount of such suspended matter assists in the liberation of steam bubbles, but an excess causes violent ebullition.

Another cause of foaming is the presence of soap in the feed water. This may be accidental or due to the feed water containing sewage. Yet another cause of soap appearing in a boiler is due to the action that takes place between a vegetable oil in the water and an alkali, especially caustic soda, which under certain circumstances is

formed in a boiler. The vegetable oil contains a fatty acid, which forms soap with caustic soda. The vegetable oil is introduced with any lubricating oil which finds its way into the feed water.

Bumping is brought about by large amounts of any solid material forming, as for instance a sudden deposition of carbonate of lime or a flake of loose scale falling off.

TREATMENT OF NATURAL WATERS TO PREVENT THE FORMATION OF SLUDGE AND SCALE, AND TO OVERCOME CORROSION AND PRIMING.

Prevention of Sludge due to Matter in Suspension.

All coarser material which is capable of being settled in still water can be removed by quiet settlement, and should be so removed in a settling tank or dam. From such settlers the water should be drawn off from or near to the surface level, wherever that may be. This can be effected by attaching to the outlet pipe near the bottom of the settler a pipe with a flexible joint, the moveable end of the pipe having a float attached to it whereby its inlet end is always just below the surface of the water in the settler.

Extremely fine suspended matter which does not settle in a tank or dam must be removed by sand filtration. Such filters are best supplied by makers, and they must be so constructed that they can be washed clean from time to time. Well-designed filters will remove fine organic matter and also most of the clayey colloidal matter when present.

Other substances which form sludge such as carbonate of lime, magnesia, oxides of iron, alumina, and manganese are removed from the feed water during softening processes for scale prevention as now to be described.

Prevention of Scale.

The aim of all scale prevention processes or treatments is either to render such scale-forming constituents of water harmless by changing their composition, or to entirely remove such substances from the feed before it enters the boiler.

The methods employed may be classed first as:—

1. Processes in which the water is treated in the boiler.

2. Processes treating the water outside the boiler before use.

Treatment in the Boiler.

This system requires the addition of some reagent added at intervals or continually added to the feed water as it is passed into the boiler. These reagents go under the terms "Boiler Compounds," "Anti-scale Compounds," "Boiler Preservatives," etc. Many of them, like patent medicines, claim to purify and render innocuous any sample of water irrespective of its contents. The best of these contain soda ash or sodium carbonate, which reacts on sulphate of lime to convert it into carbonate of lime, thus forming a soft scale instead of a hard scale. Most of them are harmless if they are not deleterious, and any of them, unless used under technical advice, should be left alone. It is only right that the legislature should compel the purveyors of these compounds to supply on the label a certified composition.

By Treatment Before the Water Enters the Boiler.

Removal of scale-forming ingredients from the water before it enters the boiler or otherwise rendering them innocuous is the only satisfactory method, hence where water has been proved to be a harmful water the boiler plant should be provided with a "treatment" or "softening" plant. The term softening is used because the treated water is a "soft" one, whereas the original water if of a harmful nature is invariably "hard."

Method "A."—By heating the water to about 320 degrees Fahrenheit before it enters the boiler. This precipitates the carbonates of lime and magnesia, also the sulphate of lime. The water is then settled and filtered before it enters the boiler. This method is necessarily a slow one.

Method "B": The Lime-Soda Process.—In this process lime in the form of lime water is added to the feed water, and this unites with the carbonic acid, which holds

the carbonates of lime and magnesia in solution. Therefore these are rendered insoluble and settle out, the carbonate of lime as such and the magnesian carbonate as magnesia hydrate.

This means that the addition of lime removes the temporary hardness constituents from a feed water by precipitation, and these can then be taken out of the water by filtration before it is feed into a boiler.

Soda in the form of soda ash or commercial sodium carbonate is added to convert the other or permanent hardness constituents such as sulphates of lime, also nitrates and chlorides of lime and magnesia into sulphate, nitrate, and chloride of soda. Sulphate of magnesia is first converted into carbonate of magnesia and then into hydrate, which, as shown above, is precipitated.

Soluble salts of iron and alumina are also acted upon by the soda forming insoluble oxides and soluble sulphate of soda.

The lime-soda plant requires an exact knowledge of the composition of the water in order that the proper amounts of the reagents may be added. There are many plants working on this principle, these being so designed that the feed water is mixed first with the exact amount of the two chemicals lime and soda, then a settling tank to remove the carbonate of lime, magnesia hydrate, and oxides of iron and alumina, followed by filtration. The water passing on to the boiler will now contain much soluble sodium salts, sulphate, nitrate, and chloride, and as the water in the boiler is continually evaporating it will become more and more concentrated in its contents of these salts. If this concentration proceeds too far there is, as previously shown, a danger that a sulphate of soda scale will form. This must be guarded against by blowing off from time to time and making up with more of the softened water. The suppliers of any softening plant will state what the limit of concentration for safe work will be. The test is a simple one, being the determination of the specific gravity by means of a hydrometer.

The main drawback to the lime-soda process is that the chemicals added must be carefully regulated, and any change in the composition of the water requires alteration in the amount of the softening reagents.

Method "C": The Zeolite Process.—This process is based upon a natural geological process that takes place when water is percolating through certain strata containing zeolites, essentially silicate of soda, etc. This has led to the formation of artificial zeolite or sodium silicate. When water containing bi-carbonates of lime and magnesia, or temporary hardness, also sulphates, nitrates, and chlorides of lime and magnesia, the permanent hardness constituents, is allowed to filter through a bed of this artificial zeolite, then the lime and magnesia are replaced by the sodium in the zeolite. This means that the water flowing away from the zeolite softener has completely lost its hardness, both temporary and permanent, and now consists of a water charged with soluble sodium salts.

This process is in results similar to the lime-soda process, but it is simple in that there is no need to control the softening by regulation of the amount of zeolite, provided the quantity used is large enough for the quantity of water. Further, variations in the composition of the water do not affect the result.

The fact must be remembered that, as in the case of the lime-soda process, the water in the boiler will soon become highly charged with sodium salts, and therefore must be blown off to keep the water below a given specific gravity.

In time the zeolite becomes charged with lime and magnesia, and then refuses to further soften the water. The zeolite can, however, be readily regenerated by passing a solution of common salt through it. In this way the lime and magnesia are removed as chlorides and the zeolite again charged with sodium, and is ready to soften more water. The process for any zeolite plant is thus a period of softening followed by a period of regeneration, and alternation must be carried out so long as a plant is in operation.

The trade names used for this process are the "permutit" and the "zerolit" processes of water softening, and there is no doubt that the discovery of this artificial zeolite has been of vast use to the steam power world. This process is quick and sure, and will give water free from hardness, and also destroys the corrosive substance chloride of magnesium.

Comparing it to a lime-soda plant, this did not always completely soften the feed water, whereas the zeolite system is certain in all cases. Further, the attention required is much simpler.

When a feed water contains much of the bi-carbonates of lime and magnesia it is, however, better to have a combination of the two systems, using a lime-zeolite water softening plant. The lime portion removes the carbonates, whilst the zeolite completes the softening dealing mainly with the permanent hardness. The reason of this is that high carbonate of lime and magnesia means that the water outflowing from the zeolite softener will contain an excess of carbonate of soda, which in a high pressure boiler will produce caustic soda which is not wanted.

Enough has been said to show the general features of water softening systems, and it will be noted that the two main systems, the lime-soda and the zeolite, are based on chemical reactions, and these reactions must vary with the composition of the water.

Prevention Against Corrosion.

As already shown, there are two main causes of corrosion, these being:—

1. Corrosion by soluble salts, as nitrates and chlorides of lime and magnesia, or of acids in the water, or acids formed during steaming, especially from the decomposition of sulphates of alumina and iron.

To prevent corrosion due to these causes the lime-soda softening system does not quite remove the hardening constituents in water, so that a certain amount of scale is formed, and this will prevent any corrosive substances from acting. This system itself acts chemically on many of the corroding constituents of water to render them inactive.

The zeolite system reacts also with any corrosive salts of lime and magnesia, converting them into soluble non-corrosive sodium salts.

Hence the softening processes which treat a feed water outside a boiler are also anti-corrosive agencies, except that process which depends upon heating the water to a certain temperature only.

2 Corrosion due to absorbed oxygen and carbonic acid in feed water Under certain conditions water may contain a lot of oxygen and also perhaps carbonic acid. Both are corrosive, especially oxygen, whilst carbonic acid is perhaps only active in conjunction with oxygen. The effect of oxygen is especially noticed in condensing steam plants, since there are several ways in which the condensed water can be mixed with air before again entering the boiler. Softening plants also give chances for water to pick up atmospheric air, and therefore oxygen and carbonic acid.

Means are now provided for degassing or rendering water inactive in this respect, since it is possible that a boiler plant, provided, for instance, with a "zeolite" softening plant, which furnishes feed water of zero hardness, and therefore having a clean shell and tubes, may yet corrode badly. This corrosion will be due to dissolved oxygen and carbonic acid in the water.

Prevention Against Priming.

The reasons for priming have been mentioned, these being briefly fine matter in suspension, soapy matter, and large quantities of solid matter suddenly formed. Fine matter as suspension such as colloidal matter and magnesia should be removed before the water enters the boiler by methods already given. As regards soap, care should be taken that the feed water is not contaminated with soap as sewage, also in return water plants lubricating oil should be taken out of the condensed water.

When a softening plant has been put in, for instance a zeolite softener, to treat a boiler feed water, and the same boiler has been previously using the same water untreated and has a scale, then it generally happens that the effect of the softened water is to soften the scale. This means that such scale flakes off and in doing so will probably cause bumping.

GENERAL NOTE.

From these notes on treatment of water it is obvious that in any boiler plant, and especially in condensing return feed installations, two preliminary operations may be

essential—namely, filtration and softening, followed by degassing of the feed water in order to prevent formation of sludge and scale, and to guard against corrosion and priming in its different forms.

The subject with many boiler waters may thus be a complex one, requiring special treatment by those trained in this class of work, and my object in writing this paper has been largely to emphasise the importance that attaches to a consideration of boiler feed supplies.

RECOMMENDATIONS.

I would, in conclusion, submit the following suggestions to those using steam power, especially where new plants are being installed, and also where boiler troubles arise:—

1. Never use a boiler feed water without having it analysed and reported on

2. Having got the analysis be sure and get it interpreted if you do not understand it.

3. Have all available sources of supply tested. This enables the best to be selected, and in case of one source running dry gives an idea which one is next best to use.

4. Be careful of the use of mine water, or water which gets the drainage of waste heaps about mines. Also note whether water is liable to contamination by sewage or drainage from industrial works.

5. Be careful of water obtained in areas liable to be affected by the sea. The rise and fall of the tide may have varying effects. Sea water brings in corrosive substances.

6. Do not use water unless all suspended matter has been removed by settlement and filtration.

7. If a water supply contains scale-forming or corrosive substances in solution have the injurious actions of these nullified by treatment.

8. Do not use boiler compounds except under technical advice. No internal treatment of water is satisfactory. Demand a certified analysis of any boiler compound.

9. Treat water to remove soluble scale-forming and corrosive constituents or the effects of these before it enters the boiler. The "zeolite" processes are, on the whole, the

best processes to use, according to present-day knowledge. Absence of scale reduces the fuel bill, corrosion is dangerous, since it weakens the boiler.

10. In a condensing plant returning the feed water, watch for corrosion by dissolved oxygen and carbonic acid. Put in a degassing plant if required.

11. In using a water softening plant which is to prevent scale watch well for corrosion.

12. When using any water softening plant be careful to adhere to the directions, and obtain from the suppliers full directions and appliances necessary to test the water before or after softening.

13. When using a softening plant obtain from the suppliers the degree of concentration allowable for the water in the boiler owing to the increase in soluble salts. Operate the blow off and make up to keep within this concentration. There is danger in overstepping it.

14. If the water is purified do not blow off unless necessary. Only blow off after standing.

BIG BLASTS WITH WELL-DRILL HOLES AND TUNNELLING.

By JOHN R. LEGGO, Nobel's Explosives Company.

Modern practice in quarrying and open-work of late years involves the use of either well-drill holes or of tunnel-shots when dealing with the blasting of large quantities of ore in the case of open-work mining and of rock in that of quarrying. It is with the intention of explaining their respective advantages over ordinary bore-hole blasting the writer has prepared this paper.

By way of comparison and in order to keep the old system of blasting before us, it will be well to review the old method as carried out in the average quarry with a face averaging, say, from 50 feet to 100 feet in height. First, there is the mechanical equipment, comprising air compressor, rock drills, air pipes, air hoses, etc. The main air pipe is laid from the compressor to the back and parallel to the quarry face. From this main air pipe right angle branches are laid off, one for each rock drill used in the face, and to these branches are connected the necessary hose lengths to feed the air drills.

In addition there are life lines, anchored securely at the back of the quarry, for men to hang on by when scaling the face to take their positions where the holes are to be bored, or when clearing loose sections of rock liable to fall on workers at the base of the quarry face. This is the daily routine in the average quarry under the old system, and I venture to say it is a most expensive method, on account of the ever-recurring waste of time in preparing for these comparatively small shots. Apart from this waste of time, the daily disturbance of the face by numerous small blasts renders it unsafe for those engaged on the floor of the quarry spalling and loading the rock. There are, of course, shallow-faced quarries that will admit

of no other system than that of individual boring and blasting, but it is not the purpose of this paper to deal with such quarries, but with those having high faces. By way of comparison we will now consider tunnel blasting and later well-hole blasting.

TUNNEL BLASTING.

In a face of 100 feet or more in height practical commonsense will decide as to the best position to put in the drive. This should be as small as possible consistent with freedom for the use of a jackhammer air-drill or for hand-boring. In the latter case more room to work in is required than with the former, but generally speaking a drive 4 feet 6 inches by 2 feet 6 inches will answer the purpose. The reason for making the drive as small as possible is to save time and expense when tamping after the charges have been laid. It also tends to a more thorough tamping and perfect closure or bottling up of the charges.

The drive for tunnel blasting is usually T shaped, the length of the stem of the T being governed by the shape and height of the quarry face, and also by the amount of rock or ore required from the shot.

Should the face exceed 100 feet in height, the main drive or stem of the T should, for a well-balanced burden, be not less than a chain in length, and the cross-drives, which form the head of the T, 33 feet each in length. Naturally, such even measurement can be varied, as for example the length of the cross-drives must be governed by the shape of the burden that is being dealt with, the amount of material expected from the shot, and the resistance to rupture of the material. Further, it is generally necessary to put out two extra cross-drives half-way between the head of the T and the face, as shown (see Plate No. 1), in order to ensure the base of the burden being completely disrupted. The drive above described with 100 feet represents an overburden of about 8000 cubic yards, but this amount would by no means cover the quantity brought down by the shot, as from my experience at least 25 per cent. more broken rock may be added. Therefore, from an adequate shot at least 10,000 cubic yards may be looked for. The charge of explosives for the above

shot. assuming the burden to be fairly regular in shape, would be 28.284 cases of blasting gelatine, based on the calculation of 7 cubic yards actual burden to be dislodged to the 11b of explosives; but in all cases one invariably gives the benefit of the doubt in favour of the explosives, and so would make it a round 30 cases.

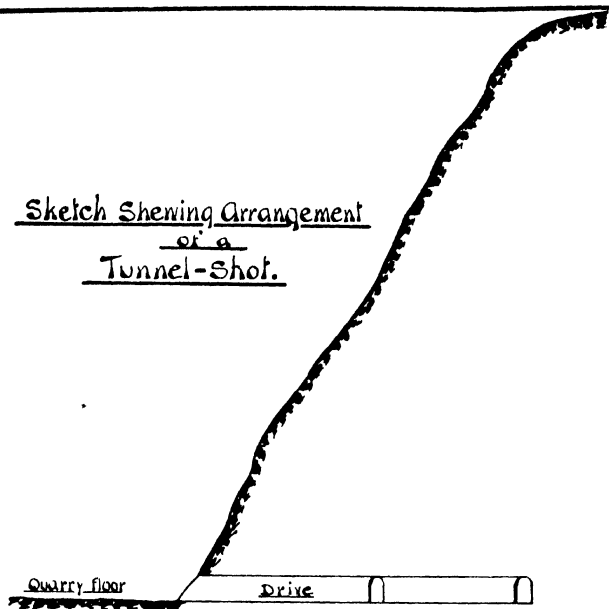
In estimating the amount of explosives for a burden, it should be borne in mind that there is no strictly reliable formula to which one can work, and each and every burden has some peculiarity needing special treatment. For example, the contour of the quarry face must be considered—whether the face is fairly perpendicular or slanting; toes and buttresses; rock solid or well fractured; conformable in its stratification or contorted; and so on. Further, if the rock is needed for road metal, then a few extra cases of explosives would ensure greater fracturing of the rock, and consequently less spalling and popping of big stuff later. A few extra cases of explosives when blasting for road metal is always good policy and is money economically spent. I have cited blasting gelatine in the above case as the explosive used, and, generally speaking, it cannot be improved on for procuring road metal, as it has the greatest shattering effect of all explosives. There are, however, other grades, such as loose powder, gelignite, gelatine, dynamite, and quarry monobel, which are more suitable for procuring of large blocks of stone for such purposes as the formation of deflection and retaining walls, breakwaters, etc

PLACING THE CHARGE.

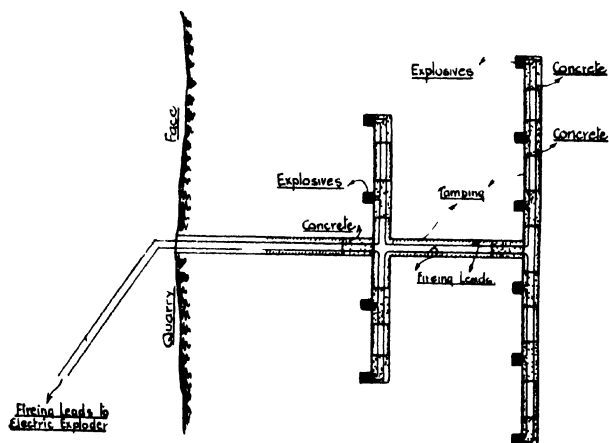
The charge of explosives is generally divided into two or more parts, and contained in as many pockets spaced in the cross-drives at distances considered to be most effective for dislodgment of the burden. The actual laying of the charges is carried out as follows:—

(a) The cubic measurement of the pockets in feet should equal as nearly as possible the number of cases of high explosives they have to hold. Allow one cubic foot for each case of 50lb of high explosive, and $1\frac{1}{2}$ cubic feet for lower grades such as loose powder and monobel per case.

Sketch Showing Arrangement
of a
Tunnel-Shot.



Section of Quarry Face.



Plan Showing Arrangement of Drives.

(b) Except for the number of unbroken cartons at the mouth of each pocket, which serves as a retaining wall, the cartridges should be emptied out of the cartons into the pocket.

(c) When each pocket is a little less than half full the primer should then be placed in position, so that on completion of the charge the primer is well embedded in the centre.

(d) For use as a primer or booster for big charges of explosives there is nothing better than a case of ordinary red dynamite, which is the most sensitive of all high explosives to detonation, and it provides an excellent kick-off to the charge. As this grade of dynamite is not always procurable, it will be well to add an extra two or three electric detonators with a cartridge primer attached, which should be connected in series and spread well across the centre of the charge. This precaution not only reduces the possibility of missfires, but it provides great help to complete and speedy combustion, which really means higher efficiency.

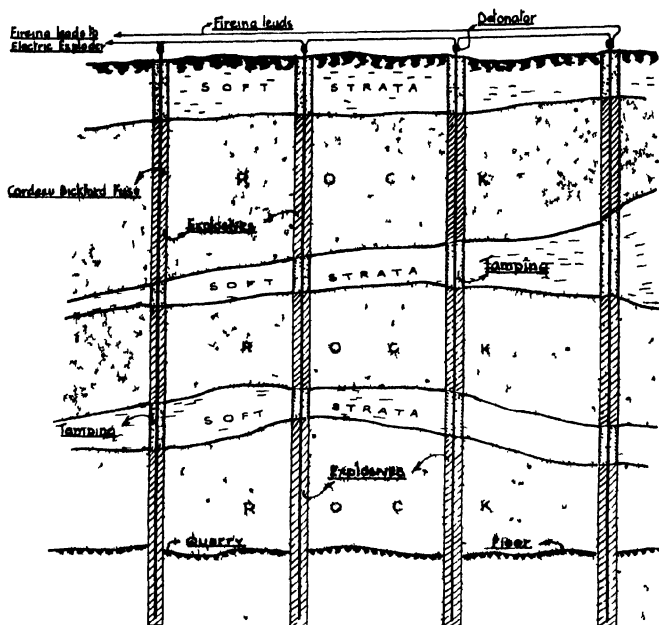
(e) It is well to have the charge neatly and snugly packed so as to leave as little air space as possible, the reason for which is so obvious that no explanation is necessary.

(f) When the laying of the charge is completed a block of concrete, say, 6 to 1 in richness, should be well packed at the mouth of each pocket, filling the drive completely for a distance of at least 6 feet, or, better still, 9 feet.

(g) The concrete should be left to set for at least 36 hours.

(h) Between the concrete blocks ordinary spoil may be used as tamping or filling, and this also should be carefully packed up to the roof of the drive. Old cement bags filled with sand or small spoil make good and easily handled filling.

(i) All electric detonators should be tested on a galvanometer, provided by the explosives companies, for continuity of current before use. Galvanometers other than those provided by explosives companies should not be used. With a resistance of 1.5 ohms connected between the terminals, the current passing should not exceed .05 ampere.



Sectional Elevation.

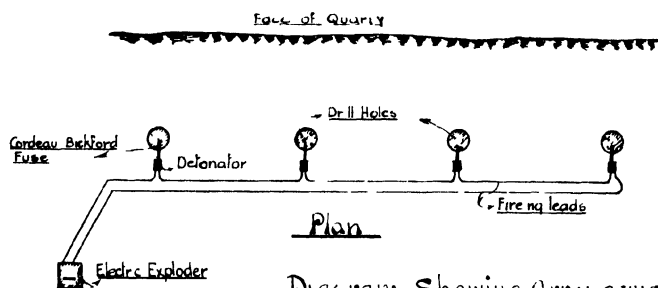


Diagram Showing Arrangement of Well-Drill Blasting.

Other makes of galvanometers may not conform to this strength, and therefore are dangerous to use.

(j) The leads from the pockets should be tested for continuity of current as each section of tamping is completed. The leads must be well protected against cutting on sharp edges of protruding rock.

(k) The men must be withdrawn from the drive to a place of safety whenever a galvanometer test is being made, and the test must be made at right angles to the drive or to the back of it a hundred yards distant, which is the length of an ordinary firing cable; never make the galvanometer test at the mouth of the drive or in front of the mouth of the drive or burden.

(l) The tamping should extend the whole length of the cross-drives, and at least two-thirds of the way out the main drive, equal care in packing being maintained throughout.

With the tamping now completed and the last of the concrete blocks having had 36 hours in which to set, the shot is ready for firing. Firing is done with an exploder of ample power provided by the explosives company or by current obtained from the electrical system connected with the works. Plate No. I (plan and section) shows the layout of this system of big blasting.

THE WELL DRILL HOLE SYSTEM OF BLASTING.

(Plate No. II.)

To describe this system a description of it, as carried out at Wilson's Portland Cement Company's limestone quarry, Whangarei, will suffice.

The Company has now (at time of writing) in readiness for charging at their quarry 15 holes, varying in depth from 154 feet to 216 feet. The diameter of the holes is $5\frac{1}{2}$ inches, and they are bored beyond the floor of the quarry some 8 feet (but 4 feet is quite sufficient) to ensure breaking the burden clean to the quarry floor. For drilling these holes a Keystone drilling machine was used, and I believe it gave very satisfactory results, the average depth bored per day being 40 feet. The 15 holes are spaced longitudinally 21 feet and back from the face 33 feet, which

represents some 77,000 cubic yards, allowing for no spreading and shattering. As there will be a considerable amount of this the actual quantity of limestone dislodged by this blast should be 87,000, or possibly 100,000 cubic yards. The charge of explosives will probably be 10 tons of blasting gelatine specially manufactured by Nobel's Explosive Company—viz., in cartridges 5 inches in diameter by 2 feet 3 inches long and 25lb in weight. These cartridges are provided with a strong cord through the centre to enable them to be lowered with safety to the bottom of the hole by means of a rope with a trip-hook at the end. These holes are not chambered to provide space for a big charge of explosives, as is often done in the case of small bore-holes, as the larger diameter in this instance allows ample room for sufficient explosives to deal with the work required.

In the ordinary way of firing such big and lengthy charges with the electric detonators it would be necessary to place at regular intervals, say, of 15 feet throughout the charge, an extra detonator to the one in the primer, to ensure speedy detonation and complete combustion of the charge; but to-day there is a detonating fuse which has a detonating speed of 17,500 feet per second, known as Cordeau-Bickford, which overcomes all sluggishness and tendency of long and big charges to burn. This fuse, which has a core of T.N.T., is encased in 3-16 inch leaden tubing, is very flexible, easy to handle, and impervious to water. When charging, the fuse is run down the full length and against the side of the hole; the cartridges of explosives are then lowered into position, and may be continuous or spaced, to meet the requirements of the burden, as in the case of alternating stratification of soft and hard layers of rock (see Plate No. II). This fuse not only insures perfect detonation, but considerably increases the speed of combustion, which means greater efficiency. Another advantage is the fact that the holes are fired at the surface; that is, instead of a primer with an electric detonator attachment being lowered on to the charge and covered with many feet of tamping, the Cordeau-Bickford extends a few inches beyond the collar of the hole, and to this portion or end of the fuse the electric detonator is fastened by means of a copper union, thereby, in case of missfire, affording the greatest possible facility to replace

a faulty detonator without having to remove the tamping or tampering with the charge in any way. Cordeau-Pickford is certainly most valuable in long holes and tunnel blasts. The advantages, both economic and resultant of tunnel shots and well drill-hole blasts over ordinary short hole blasting where either of these systems is adopted, are:

(a) In one operation thousands of tons of material are removed, while with short holes hundreds of short bore-holes have to be drilled, charged, tamped, and fired for the same result.

(b) The daily recurrence of shifting the drilling appliances trimming down the face and carrying out other preparatory work is entirely eliminated.

(c) The driving for tunnel blasts or the boring for well-hole blasts need not interfere with the usual business of the quarry or mine.

(d) The cost of broken material per cubic yard is very much in favour of big blasts.

(e) The cost of handling the material after its dislodgement is very much cheaper, whether it be man-handled or handled by machinery, than that of small burden shots; in fact, the general advantages of big blasts over ordinary boring and blasting cannot be too highly emphasised.

In conclusion the following particulars, accompanied by a detailed plan (see Plate No. III), of a big blast which took place at the Mosgiel Railway Quarry on August 12, 1911, under the writer's supervision for Mr Hunter Macandrew, District Engineer, Dunedin, and later Assistant Chief Engineer of New Zealand Railways, may be of interest and serve as a guide to some. The comparative pre-war and present-day costs are given. To-day's prices for the same grades of explosives as mentioned in Mr Macandrew's reports are:—

Monobel, 1s 4d as against 1s 1d per lb.

Dynamite, 1s 4½d as against 1s 1d per lb.

Wages, say, about 30 per cent. higher. This would bring the cost per cubic yard of that shot to about 3½d per cubic yard covering all costs, which for winning hard blue metal to-day is not excessive.

COST

Excavation of drive and chamber £ 69-5-1
Laying charges and stemming 26-11-8
Explosives, caps, etc. 6-1-0
Cement for concrete stemming 3-13-0
Monobel 2000 lbs. @ 1/- 100-0-0
Dynamite 250 lbs @ 1/11 13-10-10
Total £ 219-1-7

RESULT

The whole face was blown out and the material is now lying in the position indicated by the section-line D-E. In addition to this the hill is shattered to such an extent that it is only being kept up by the material which was shifted bodily by the explosion. This means that it will all come down without further shooting.

NOTE: The charge occupied the whole chamber and concrete stemming was used to make the chamber airtight. This immediately behind the charge.

ESTIMATE

Estimated quantity of rock thrown down into quarry 5000 cyds.
Estimated quantity of rock shattered sufficiently to come down without further shooting (much of this will come down when the loose material now supporting it is removed) 16000 cyds.
Total 21000 cyds. = 42000 tons.

COST PER CUBIC YARD

£ 219-1-7 = 2½ d. per cyd.
21000

TONNAGE RATE

Estimate of tonnage shifted and = 42000 = 18.6 tons.
shattered per lb of explosive 2250

H. MACANDREW
DISTRICT ENGINEER

THE LUBRICATION OF MINE EQUIPMENT.

. By J. C. LEITCH.

It is not my object in this paper to discuss methods of refining and the manufacture of lubricants, but rather the relation of lubrication to the efficient operation of mining machinery. In the first place, the paper deals with the general principles of lubrication, followed by their special application to the more important types of mining equipment commonly met within New Zealand.

The fundamental principle of lubrication is to eliminate avoidable friction to enable machinery to work efficiently and to reduce wear and tear. It is of primary importance to adopt such lubrication practice as will promote these results with the lowest possible operating cost. The problem is fundamentally the same, whether the lubricant is performing its function in a steam cylinder, plain bearing, or in the more complicated lubrication system of a high speed steam engine. The vital need in any particular service is the use and correct application of a lubricant which will best suit the operating conditions.

Hence, in selecting an oil for a specific purpose, it becomes necessary to study the conditions which the oil must withstand in service, the final decision being governed by an intimate knowledge of the behaviour of the lubricant under similar conditions. In the selection of lubricants for an entire plant where the equipment is somewhat varied and extensive, all manner of conditions are present. Hence, it is necessary to compromise to a certain extent, as it is obviously not practical to select a lubricant which will ideally suit each individual set of conditions.

Many attempts have been made to draw up lubricating oil specifications with the object of providing the user with an oil which will meet his requirements and allow him to

make a selection from a number of oils which conform to the specification. Oils possessing widely varying qualities may conform to the required physical tests, as usually outlined, but at the same time may be quite unfit for the service in view.

The practice of employing specifications is desired only to the extent that it protects the oil user by insuring that oil supplies are always up to the same standard. So long as a specification is employed as a protective measure and not as a selective instrument, it is of some value.

The lubricant should be selected as far as possible on performance, the crucial test being the ultimate cost of operation and production. In considering the economies of lubrication, the cost of the lubricants themselves may be almost negligible in comparison with items which may result from the use of incorrect lubricants—viz., cost of repairs, replacements, power, shut downs, or delays, even if the savings which may be effected in the consumption of the lubricant itself by efficient lubrication are not considered.

STEAM ENGINES.

The lubrication problem for steam engines naturally falls into sections: (1) Cylinders; (2) Bearings.

1. Cylinders.—The importance of efficient internal lubrication of steam engines is not generally realised. Improper lubrication results in abrasion and steam leakage, with consequent loss of power and excessive oil consumption.

There are two methods of introducing cylinder oil to the internal wearing surfaces of a steam engine. Firstly, the direct method, by means of which the oil is introduced direct into the cylinder or valve chest. Secondly, the indirect or modern method by means of which the oil is introduced into the flow of steam.

The first method has the disadvantage in that as cylinder oil is very heavy in body it spreads only with difficulty. It is apt to over-lubricate some parts and not reach other parts. For this reason a great deal of oil is required in order to insure that a complete lubricating film is maintained on all surfaces.

In the second method an entirely different principle is involved, as the steam itself is made to convey the oil to all parts requiring lubrication. It is, however, not sufficient to merely introduce the oil into the steam pipe or flow of steam, as the oil then is merely pushed along in the form of drops. It is very important that the steam should be permeated with the oil, and this can best be accomplished by means of an "atomiser," a very simple appliance illustrated in Figure 1.

Experience has shown that where a cylinder oil is completely atomised and in this form introduced into steam engines, the maximum benefit is derived from the oil, and it becomes possible to lubricate more efficiently with a smaller quantity than by the old methods of lubrication.

There are two main types of lubricator, hydro-static and mechanical force feed. The latter is the more modern and efficient method, and has the advantage that the oil feed is uniform, completely automatic, is not liable to choking, and is unaffected by changes in temperature or viscosity of the oil.

In haulage or winding engines, where operation is intermittent, the best method undoubtedly is to use a mechanical lubricator, feeding the oil into the main steam line through an atomiser, the point of oil entry depending on the steam pipe arrangement.

The lubricator stops feeding when the engines comes to rest, and swabbing of rods or supplementary feed through dose cups is unnecessary. In winding engines, due to better lubrication, the reversing lever will be easier to operate, and less power will be consumed in friction, giving more rapid acceleration. The steam can thus be shut off earlier when the cage is nearing the end of its journey, providing greater safety.

Many examples may be cited where improved results have been obtained by adopting more efficient methods of application of cylinder oil. The following example will denote the degree of saving which is possible.

A colliery fan engine (large slide valve with expansion valve) used eight gallons of cylinder oil per week through sight feed hydro-static lubricators and tallow cups. A

mechanical lubricator of an improved type was fitted, introducing the oil through an "atomiser," the result being that the oil consumption was reduced to $1\frac{1}{2}$ gallons per week—i.e., less than one-quarter of what it was previously.

Having discussed the methods of applying the oil, it will be as well to discuss briefly the factors which determine the selection of a cylinder oil for any engine. The main factors influencing the selection of a cylinder oil are steam pressure and quality. Other factors which affect the selection are size, design, speed, load, impurities, and the disposal of the exhaust steam. The paramount consideration is the temperature of the steam and its quality, whether wet, saturated, or superheated.

High steam pressure or high degree of superheat means high temperature, which requires a cylinder oil of greater viscosity.

With wet steam there is a tendency for the oil film to be washed off the internal surfaces. Thus a cylinder oil with the required amount of fixed oil for the degree of wetness present should be used, the fixed oil being of such a nature that a tenacious film will be maintained in the presence of water.

For superheated steam conditions it is extremely important that minimum oil feed should be employed, just sufficient to make up losses from the oil film, as excess oil will collect in various spaces and behind the piston rings and bake into gummy or hard deposits. It is, therefore, essential to use only the highest quality cylinder oil for engines using superheated steam.

In the case of surface condensing engines, or where there is danger of the oil getting back into the boilers, it is sometimes desirable to use a straight mineral cylinder oil which will separate readily from the condensed water. However, more oil is required for efficient lubrication, and often best results will be procured by using a slightly compounded cylinder oil, which will give good lubrication when fed in very small quantities. The fitting of oil extractors in the exhaust steam line and efficient filters will assist in preventing the oil finding its way into the boilers

2. Bearings.—Two main systems of lubrication are employed:—

- (a) Force feed circulation as for high speed enclosed steam engines.
- (b) Separate oiling devices as for the various bearings of open type engines.

(a) **Force Feed Circulation.**—In this system an oil pump forces the oil under pressure to all bearings, draining back to the sump, and in this way circulating continuously. This is the most efficient system, though a more severe duty is imposed on the oil. Oils for this service in an enclosed high speed steam engine must be able to withstand the action of water and air in the presence of heat and impurities.

To minimise the trouble from accumulation of water, wiper glands should be kept in first-class order. The oil which is carried up from the crank chamber and scraped off, together with the water from the piston rod glands, should be drained outside the crank chamber, and these drains kept clear. With superheated steam less condensation occurs in the cylinders, and therefore less water finds its way through the glands.

The danger of water accumulating in the crank chamber, apart from the severe duty placed on the oil, is that the pump may deliver this water to the bearings instead of oil. For this reason the strainer should be at a sufficient height from the bottom of the crank chamber, to prevent water from rising as high as the oil pump suction. Water should be drained from the crank chamber at frequent intervals—once a day, preferably before starting up, if the engine is shut down over night.

Safety in operation and economical oil consumption is obtainable only by the use of highly stable and suitable lubricants, combined with proper treatment of the oil whilst in service. Continuous treatment is the most efficient, but where this is not practicable it is good practice to withdraw 6 to 10 per cent. of the total oil charge from the crank case each day for treatment by some efficient filtering or clarifying equipment, the reconditioned oil being returned next day when a further charge is drawn off.

The temperature of the oil in the crank chamber should be taken regularly and entered in the log book. Under normal operating conditions this temperature is usually less than 140 degrees F., although in some large engines this temperature may be exceeded. It becomes necessary, then, to cool the oil and maintain it at a temperature below 140 degrees F., since oxidation of the oil occurs, with consequent increase in the amount of sludge formed when the temperatures are much above 140 degrees F. The cooling can be accompanied by placing cooling coils in the bed of the crank chamber, and preferably they should be made of seamless copper tube without joints in order to prevent the leakage of water into the oil system.

(b) Separate Oiling Devices — These may be either sight feed or wick feed oilers, ring oilers, or in some bearings hand oiling devices. In certain cases, such as for the crank pins of winding engines, grease cups are fitted.

The best method of lubrication is undoubtedly a circulation system, in which the bearings are continuously flooded with oil. Ring oiling is the next in order of efficiency, though this is suitable only for crankshaft bearings.

Sight feed and wick oilers supply oil regularly to the bearings in small quantities, but possess the disadvantage that the oil supply is limited and it is more difficult to collect the oil for re-use. However, very economical oil consumption is possible if all the oil escaping from the bearings is collected in trays or save alls, treated, and used again. In this respect a good quality oil will provide a saving, as, besides providing a greater factor of safety in the bearings, a much greater percentage may be recovered and used again in the engine.

No matter how small the engine may be, it is advisable to fit these automatic oilers, as hand oiling is extremely wasteful, and, due to its intermittent nature, is not so safe.

With regard to grease lubrication of crank pins or other parts, suitable oils are far preferable to grease, as they give much superior lubrication. Greases, however, are convenient in some cases. The grease is dependent for its

lubricating properties on the mineral oil content, which, as indicated previously, is carried by the soap which the grease is based on. This soap undoubtedly adds a frictional load to the machinery and somewhat restricts lubrication, and correctly selected oils when fed by drop feed oilers or similar appliances will give the best results, even where comparatively heavy pressures are encountered.

ELECTRIC MOTORS.

The bearings are generally ring oiled, though very small motors are fitted with syphon oilers, and there is an increasing number of motors using ball or roller bearings grease lubricated.

The trend of modern practice is towards much finer clearances between the windings, and very little wear of the bearings will lead to electrical losses, commutator troubles, etc., and even to contact between the rotor and stator windings. It is therefore essential to provide efficient lubrication at all times, and for ring oiled bearings a good quality oil should be used.

As most motors run at comparatively high speeds a light-bodied oil will provide best results. Particles of grit or dirt which may enter the oil reservoir of ring oiled bearings will readily settle to the bottom, and a clean oil film of high lubricating value is ensured. Moreover, a light-bodied oil is most quickly distributed over the entire bearing surface on starting up, thus reducing metallic contact to a minimum.

Always keep a high quality oil at the proper level in all ring oiled bearings; be sure that the oil is changed occasionally, that the oil wells are clean, and high efficiency and long life of the bearings will be obtained.

Ball and roller bearings are usually grease packed, but where housings are oil-tight oil is a more suitable lubricant. The efficiency and life of these bearings is dependent upon the maintenance of the various parts in their original high state of finish. A certain amount of rubbing action takes place, and if bearings of this class run dry they become noisy and produce impact loads on the parts.

A lubricant is therefore required which is free from acids or impurities, and if grease is used it should be of

such consistency that it will follow the balls without channelling and insure a complete covering and seal to prevent corrosive action.

AIR COMPRESSORS.

The air cylinders are usually fitted with sight feed oilers of the usual air compressor type, but for more important units mechanical lubricators are the most efficient. The bearing problem is very similar to that for steam engines, which has been previously discussed.

The primary need in the lubrication of air compressor cylinders is minimum oil feed correctly regulated. Most of the troubles experienced in the operation of air compressors can be traced to the use of an unsuitable or poor quality oil in the air cylinders. Due to the oxidising effect of heated air, high stability is the predominating requirement in the oil. A heavy-bodied oil is undesirable, as it will not spread readily over the cylinder walls; it will cause undue friction and tend to collect impurities from the air, which are baked into deposits.

Only enough oil should be used to furnish lubrication; that is, only enough to keep a very thin film on the cylinder walls and valves. The oil is neither burned, vaporised, nor washed away. Therefore a small quantity of the correct oil will maintain the necessary oil film and piston seal. With the correct high quality oil in use the presence of any deposits on the valves means only one of two things, either too much oil or dirty intake air.

The correct feed may be gauged in practice by examining the discharge valves, to see if they are clear of oil or deposit—i.e., provided the correct oil is in use. Too much oil feed will cause the discharge valves to stick up and thus allow of recompression of the hot compressed air, causing excessive heat. The resulting high temperature may vaporise the lubricating oil or form carbon deposits, and ultimately in extreme cases will lead to explosions in air lines and receivers.

The compressor, including cylinders and water jackets, should be examined every six months and thoroughly cleaned if efficient operation is to be maintained. A good cleaning medium for the cylinders is soft soap and water, in the proportion of 1 to 15; products such as kerosene must on no account be used.

It is good practice to pass this soapy mixture through the lubricator instead of oil about once a week at about ten times the rate of feed. After using soap suds the whole air system should be completely drained out and oil used again for about half an hour before shutting down the machine, in order to prevent rusting of the cylinders and valves.

MINE CARS.

The type of car usually employed in New Zealand is fitted with a pedestal or cod bearing, and a semi-fluid grease is applied by a Hadfield or similar type disc oiler. In some cases, where the plant is not very extensive, the grease is applied by hand.

The disc oiler is very wasteful; also coal and other dust finds its way into the trough and tends to destroy the lubricating properties of the grease when applied to the axles.

A much more efficient method is to use some form of positive acting pump actuated by the truck axles. An illustration of a suitable automatic pump oiler is given in Figure 2.

The oiler has to be well made; in fact, it cannot be too well made. It is a more expensive fitting than the ordinary disc oiler, but if well constructed will last without replacements for a considerable period. On the surface the oilers should not be exposed to the rain, but placed under a roof or shelter. Underground they should be laid down in a dry place and not where water is likely to come in contact with them.

It must be understood that this oiler can only be used when the diameter of the car wheels are all approximately the same. If this were not so the oiler could not be regulated to feed an equal amount to the axles of every car.

In this type of appliance oils provide superior lubrication to grease, although semi-fluid lubricants such as the usual skip grease at present being employed in New Zealand is operating satisfactorily. Oil will show a great saving in power and considerably reduce wear and tear, and in addition will enable skips to be more easily man-handled.

The oiler, as described above, with oil may quite easily show a saving in consumption up to as much as 50 per cent.

Where grease is in use with these contrivances consumption has been reduced to a quarter of that of the disc oiler, due to the fact that just sufficient lubricant is applied to each axle. With a disc oiler a great part of the grease is lost by deposition on the track. In very wet pits grease has some advantages, especially where oilers are placed far apart, as it is not so easily washed from the axles.

WIRE ROPES.

The lubrication of wire ropes is important. Excessive wear and corrosion of the wires in the strands may be prevented by proper lubrication.

The lubricant used should be sufficiently fluid to penetrate to all strands, and yet not be thrown off and wasted, and also form an elastic coating preventing external wear and corrosion. The protective coating must not harden on exposure to the air, as cracks will tend to form whilst bending over the winding drums, etc., allowing free access of moisture and other corrosive agents.

Grease is unsuitable, as it will not penetrate completely unless heated, and on heating its properties are permanently altered, due to the separation of the oil from the soap base of the grease. Tar is also unsuitable, as it forms a hard shell on the outside of the rope and does not penetrate to the internal parts, and it also possesses poor lubricating qualities.

A viscous, straight mineral residual petroleum product is the ideal lubricant, as it will penetrate readily when heated, and retains its original character and lubricating properties, thus providing good protection at all times. This lubricant should be applied hot to clean surfaces, so that it will penetrate properly and adhere to the rope. It may be worked into the rope by brush, paddle, or swab, but preferably some form of rope oiler should be used. Simple methods are illustrated in Figure 3 and Figure 4.

GEARS.

It is not intended to discuss the question of gear lubrication generally, but only as applied to haulage machinery. In this type of gearing there is considerable shock or impact, and pressure between the teeth is fairly severe. Irregular load conditions result in irregularity of tooth pressure, which increases shock and noise.

The usual method of lubrication is to apply grease by means of brush or paddle. Some greases are better than others for this heavy duty, but the majority are quickly squeezed out from between the bearing surfaces of the teeth and thus wasted.

A lubricant is required which will cushion the teeth, prevent shock and noise as much as possible, and provide the necessary degree of lubrication between the surfaces of the teeth. It has been found from experience that the most satisfactory lubricant is one which will maintain a film between the teeth even under very heavy pressures and will not be thrown off.

A similar product to that for wire rope lubrication is suitable for this purpose, and a little thought will show the reason for this. The wire rope in passing over the winding drum is subjected to heavy pressures, tending to displace the lubricant, and the elastic coating which is desired in the case of wire ropes is equally desirable for cushioning gears.

Hence a very viscous residual petroleum product will form the most efficient lubricant for heavy duty gears. Such a product will allow of very great reduction in consumption compared to the greases usually employed on this service, and at the same time will improve the cushioning and reduce the wear of the teeth. It should be applied hot to clean surfaces if the maximum results are to be obtained.

CONCLUSION.

In conclusion, whatever the methods of lubrication adopted, the maximum economy will only be obtained by efficient storage and handling of the lubricants.

The system which should be adopted in any colliery depends upon the local conditions. It is not possible within the scope of this paper to discuss the various advantages of different systems of oil storage; and for the same reason the subject of the lubrication of such equipment as coal cutters, pneumatic tools, etc., had to be omitted.

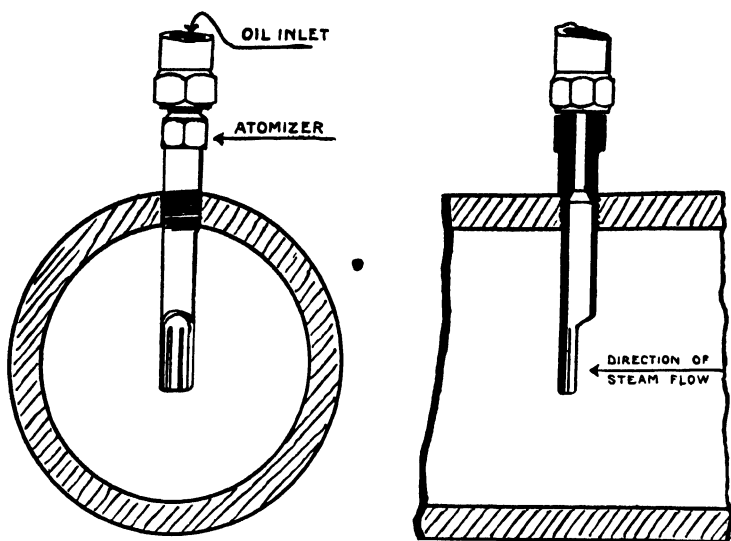


Fig. 1.

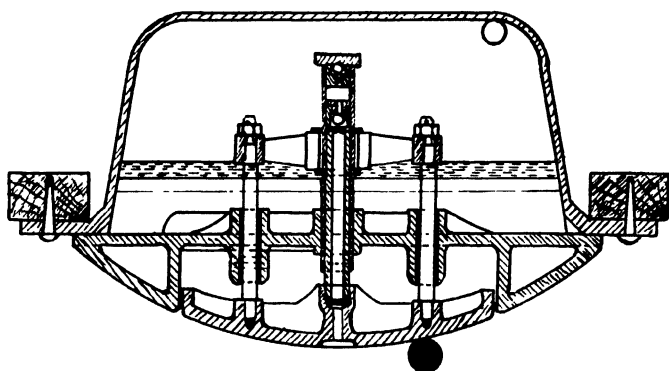


Fig. 2.

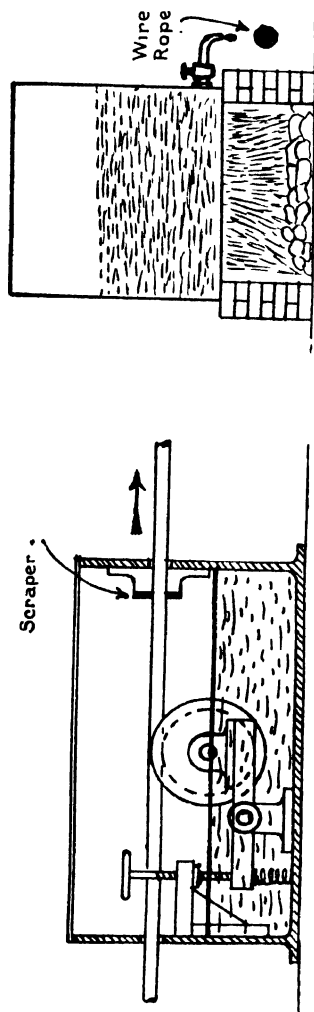


Fig. 3.

NEW ZEALAND IRON INDUSTRY.

BY J. A. HESKETT

An important step has been made in establishing an industry of great importance to the Dominion.

Although New Zealand does not absorb more than 11,000 tons of pig-iron per annum, the whole of this trade was supported by imported iron, leaving the consumer at the mercy of shipping strikes and other contingencies, such as the late War, when pig-iron was at a premium.

The annual requirements of iron and steel for New Zealand are small, and is stated in the Year Book as hereunder:—

Pig-iron	...	...	...	11,000 tons
Steel Rails	...	...	...	25,000 „
Corrugated Iron	...	...	...	20,000 „
Plain Fencing Wire	...	...	...	10,000 „
Bar Iron	.	...	...	25,000 „

The Onakaka Iron and Steel Company was formed with the expressed intention of manufacturing pig-iron from the iron ore deposits at Onakaka.

This is a portion of the iron ore deposits situated near the foreshores of Golden Bay, in the north-western portion of the South Island, being about one and a-half miles from the seashore, and running almost parallel to the coast.

The deposit exists as a cap of iron ore on a hill extending approximately five miles, and includes the Para Para leases on the northern end and the Onakaka leases on the southern end; also the Tukurua Block, which lies midway between the two leases.

The hill gradually rises from sea level at the northern end to about 1500 feet at the extreme southern end of the Onakaka lease.

The hilltop varies in width from about 5 to 15 chains, and the deposits are broken in a number of places on the ridge, where limestone and at times quartz replaces the iron ore.

On the Onakaka lease limestone replaces the iron ore, and on the Para Para lease quartz predominates where the iron deposit is interrupted.

The depth of iron ore has been proved at the Para Para end to exist 200 feet below the surface, by the means of long tunnel drives. At Onakaka slips that are frequent on the slopes of the hill have exposed iron ore bodies 400 feet below the crest. The iron content of the ore exposed at 100 feet is low, being approximately 35 to 40 per cent iron, the iron being replaced by silica.

In estimating the quantity of iron ore in sight on the Onakaka lease, it is very difficult to do more than approximate the amount in the absence of prospecting drives and systematic sampling.

Where the ore exists there is no overburden, and the outcrop is only broken by the limestone deposits cropping up between heavy bodies of iron ore. The limestone deposits run at right angles across the hill, and extend approximately five chains in length by 10 chains in width, and to a known depth of 900 feet.

The following are analyses of the iron ore and limestone of average samples picked by a Mines Department official, and analysed at the Government Laboratory, Wellington: -

				Iron ore		Limestone.	
				Per cent		Per cent.	
Fe_2O_3	..	...	...	71.66	..	...	1.76
FeO	...	.	...	—	...	..	—
SiO_2	...	...	...	12.13	...	...	10.26
Al_2O_3	...	...	...	2.79	...	...	2.12
TiO_2	...	...	...	.20	...	...	.17
CaO	..	...	...	10	...	...	47.10
MgO	...	..	...	.33	...	...	1.24
P_2O_5	..	...	...	.23	...	...	.07
MnO	...	...	..	.72	...	...	—
S	...	...	...	.13	...	...	.21
Loss on ignition	..			12.01	...	...	37.18

100.30

100.11

The iron content of the ore is 50.16 per cent and water 12.01 per cent, showing a limonite ore.

The iron exists in the limestone as pyrite, which appears oxidised at times on the surface.

The amount of iron ore in sight represents many million tons, and what appears a very safe estimate is 20,000,000 tons of high-grade ore, and a considerable higher percentage of lower grade, running between 30 and 40 per cent iron.

The limestone is used for fluxing, and is very conveniently situated being quarried and handled alongside the iron ore face.

The point where the iron ore and limestone is being worked is 1200 feet above sea level, which is the southern end and lowest portion of the Onakaka lease.

The iron ore exists to a great extent like "buns in a basket," huge boulders as "buns," and between the boulders a considerable amount of clayey material. Some of the boulders weigh over 200 tons.

The deposit is shattered and the crevices have filled with the laterite material at a later date.

The quarries are 1100 feet above the blast furnace and plant.

A portable Ingersoll Rand combination compressor and jackhammer outfit is used for drilling, and sluicing is employed from storm water conveyed by a race, when available to dispose of the debris not available for smelting.

The iron ore and limestone is conveyed by a monorail aerial tramway one mile and a-half long to the bins which are situated on a hill at the back of the blast furnace foundation.

The capacity of the aerial tramway is small, handling only seven tons per hour. The aerial works smoothly, and is controlled by a rope drive and gearing from a countershaft, controlled through a friction clutch from the engine room.

Once the line is started there is sufficient weight in the full buckets to maintain the speed, which is further controlled by hand brakes, if necessary, by the boy employed to right the buckets after they have tipped the ore or limestone automatically into the crusher.

The ore and limestone are crushed in a Blake jaw-crusher to 2½ in, after which it is conveyed by an 18 in rubber conveyer belt to their respective bins. The bins are reinforced concrete substantially constructed.

The blast furnace is a small hand-filled furnace with a bell and hopper delivery into furnace.

The height is 55 feet, bosh height 10 feet vertical, angle of bosh 65 degrees, hearth 5 feet diameter. The lining of furnace up to the top of bosh is made of local fire clay rammed into place between a wooden form and shell of hearth and bosh.

The hearth is pierced with cast-iron cooling blocks, with water circulating through a pipe coil imbedded in the cast-iron.

There are six tuyres and coolers. The coolers are cast iron, with a wrought iron pipe coil imbedded in same, and through which water circulates. The tuyre itself is made of bronze, and seats into cooler, projecting into furnace six inches past nose of cooler.

The bosh of furnace is made of mild steel in one piece, welded by oxy-acetylene torch to give an even surface over which water passes from a spray on top of bosh. The waste water is caught in a launder at bottom of bosh and carried away.

The iron ore, limestone, and coke are taken delivery of from their respective bins by hand-barrows specially constructed, weighed, and then lifted by hydraulic lift to the top of furnace, where it is delivered from barrow into hopper on top of furnace.

The slag is tapped at regular intervals, and disposed of by granulating with water and washing over the hill-side, where a splendid tip head has been arranged.

Six to seven tons of molten iron is tapped every six hours and allowed to run 50 feet down a main runner, where it is split into two channels and falls into cast-iron moulds arranged on bearers sitting on wheels, which are hauled by a substantial friction winch at the speed desired to suit the flow of metal.

When the metal sets in three to four minutes' time, the moulds are hauled on top of a gantry and capsized, where the pig-iron is delivered into a stack ready for shipping.

The moulds are suitably nicked, so that there is ease in breaking the iron by users into lumps approximately four inches square.

The pig-iron is hand-loaded on to trucks running on a two feet six inches gauge tramline, and lowered by winch on a self-acting incline to meet the main rope haulage, from where it is taken to the wharf.

The wharf is situated one mile and a-half from the works. It is 1210 feet long, giving a depth of eight feet at dead low water and 22 feet at high water.

The wharf is built of local timber, and has been erected two years. The torado has made so serious a ravage on the piles that they have been reinforced by driving 90lb tram rails alongside one on each side of pile, and suitably bolted to wooden pile. These have been braced by similar rails 40 feet long.

This has given stability sufficient to carry a 600-ton bin, which stands 16 feet high above the deck, six feet being the distance between the wharf and bottom of bins, where the trucks run underneath to take delivery of coal.

The coal used is State coal from the Liverpool Collieries, Greymouth, and conveyed by 800 to 900-ton vessels and discharged into bin on wharf.

The coal, after being delivered into trucks of one ton capacity, is shunted on to a main and tail haulage system and conveyed to the works one mile and a-half away and up an incline to top of 300-ton capacity coal bins at the coke ovens, which is 42 feet high. The coal is kept dry.

From this bin a 6-ton truck takes delivery of coal, and is hauled by a small endless rope haulage to the tops of ovens and discharged through the eye in crown of same.

The ovens are of the beehive type, 16 being 12 feet in diameter and 6 feet 6 inches high in dome, with ordinary brick floor. The other eight are 13 feet in diameter and 7 feet 6 inches high from floor to dome, and have flues under floor.

The 16 ovens are much slower in coking time, taking 56 hours with a 6-ton charge, as against 36 hours in the bigger ovens. The flues under the oven floor give a parting in coke about four inches from the bottom, which gives small coke and is not so easy to draw.

The coke is cooled in the oven by a water spray, and raked out by hand labour and loaded direct into trucks and conveyed to bins. The amount of breeze made averages 120lb from a 6-ton charge of coal. All coke over half an inch is delivered to the blast furnace.

The shutes from bins have screens, which discard coke below half an inch in diameter. The screenings drop into a trough and are washed away with water.

The power is supplied from three boilers, a Babcock and Wilcox, a Multitubular, and a marine type boiler. The most satisfactory is the Multitubular, as the tubes can be cleaned daily from the heavy fumes which settle out of the waste gases from the blast furnace used for firing.

This fume is of a grassy nature, and precipitates on to the walls of tubes and is very hard to dislodge. It insulates and renders the steaming efficiency of boilers very low until the tubes are cleaned. Gas washing is not resorted to.

The analysis of gas from blast furnace, which is burnt in hot stove and under boilers, averages:—

CO ₂	...	...	...	10.4	per cent.
CO	...	..	..	27.6	„ „
Nitrogen	...	...	...	61.0	„ „
Hydrogen	...	...	...	0.2	„ „
Hydrocarbons	...	...	...	0.8	„ „

This gas has a heating value of approximately 90 BTU per cubic foot.

The blast supplied to the blast furnace is delivered at a pressure of 30 ounces from a substantial Roots blower, having a capacity of 64 cubic feet per minute. The air passes through 24 cast-iron U pipes suspended in a brick stove. The pipes are coupled together in three rows, and attached to a manifold at each end.

The blast enters the same end as the burning gas, which is termed a parallel current. The counter current where the gas comes in at the opposite end to the air took less gas to heat the air to 1000 degrees Fahrenheit, but was very severe on the cast-iron pipes. The parallel current has not shown any sign of scaling of pipes.

The temperature is controlled by a Bristol pyrometer, which indicates the temperature at the furnace on an indicator, and is recorded in the laboratory on a 24-hour smoked chart.

The air supplied to the furnace is controlled by pressure gauges and also a tachometer, indicating revolutions, which was supplied by Messrs A. B. Bailey and Co., Ltd, Manchester.

Plenty of water is available at a pressure of 110lb per square inch, and Pelton wheels are used wherever necessary. Water is brought by a wooden flume three-quarters of a mile along the hillside and delivered into a 13in pipe line, and thus conveyed a further three-quarters of a mile to the works. There is 10 heads of water available in the average dry weather, with a splendid gorge for a catchment area if required later to conserve storm water.

A nicely equipped laboratory where daily analyses of pig-iron is undertaken facilitates the control of the furnace, the main analyses being the determination of silicon and sulphur. These elements are determined by rapid methods, the sulphur by evolution as H_2S and absorbed in cadmium chloride solution, which is dissolved and titrated with a standard solution of iodine. The silicon is determined by a gravimetric method.

The present practice is to produce foundry pig-iron, and an average analysis is:—

Graphitic carbon	...	...	...	2.9
Combined carbon	...	...	...	.2
Silicon	...	...	...	2.8
Sulphur	...	...	...	.03
Phosphorous	...	...	...	.3
Manganese	...	...	...	.6
Iron by difference	...	...	...	93.17
				100.00

This is produced with the following burden:—

				lb.
Iron ore	..	...	...	2,128
Limestone	...	...	...	812
Coke	...	...	...	1,000

The average slag analysis runs:—

SiO_2	...	...	...	40.10
Al_2O_3	...	...	...	11.90
FeO	...	..	...	1.80
TiO_2	...	...	...	.3
CaO	...	...	...	41.3
MgO	...	...	...	1.3
MnO	...	...	...	.6
CaS	...	...	...	2.4
				99.7

The coke used averages when dry:—

Fixed carbon	...	...	...	88.8
Hydrocarbon	...	...	...	1.2
Ash	...	...	...	9.6
Sulphur	...	...	...	.36
Phosphorous	...	...	...	.04
				100.00

There is an abundance of limestone and dolomite within the vicinity of the works. The limestone being used is the deposit adjacent to the ore deposit, and although somewhat high in silica is handled very cheaply.

Dolomite for steel furnace lining is located near the Mount Burnett coal field, about 10 miles from Onakaka, and about one mile from the foreshore of Golden Bay. It exists in a massive cliff formation, extending over a considerable area, with the face of the cliff hundreds of feet in height. It is easily accessible. An average analysis is as follows, taken from bulletin of Geological Survey of the district:—

SiO ₂	.	...	...	...	.62
Al ₂ O ₃	...	...	...	..	.01
Fe ₂ O ₃	.	..	...	...	32
CaO	..	..	...	..	36.11
MgO	...	...	...	...	16.50
CO ₂	...	...	...	...	46.40
Organic matter and H ₂ O	...				.04

100.00

The coal measures within the vicinity are faulted and lenticular, and no serious attempt has been made to work them of recent years. There are quite a number of seams ranging about three feet to five feet in thickness, with occasional bands of stone, which come in and go out at various points. The coal is excellent coking coal, and easy of access in some instances, but not so in other cases. An average analysis is as follows:—

Fixed carbon	...	...	..	50.1
Ash	...	...	..	5.6
Sulphur	...	...	..	.5
Volatile hydrocarbon	...	...		12.5
Water	...	...	...	1.3

100.0

The local fire-clay used in the furnace lining stands up to its work very satisfactorily, and, according to the Dominion Laboratory report, averages:—

SiO ₂	..	...	..	..	64.63
Al ₂ O ₃	..	...	..	...	24.19
Fe ₂ O ₃	..	..	..	..	.88
TiO ₂		..	.	.	.92
CaO	...	...	...	...	.26
MgO	.	..	.	.	nil
K ₂ O	.	..	..	.	nil
Na ₂ O		...	.	..	.33
Moisture lost at 105° C.	...				.67
Combined water and organic matter	..	...	..		8.31
					100.19

The future prospects of the industry appear promising. The present outlet for the pig-iron produced is the Dominion market. The present cost to mine and deliver iron ore and limestone to the furnace is 3s 6d per ton, and with increased tonnage this figure can be considerably reduced.

With a modern plant capable of producing 300 to 400 tons of pig-iron per day, New Zealand should produce a pig-iron at a cost that would allow it to compete with other exporting countries, particularly to markets on the Pacific coast of America. Freight prices from New Zealand to San Francisco encourages this belief, being less than coastal freights in New Zealand from Onakaka.



Figure 1 —Iron Ore Quarry.



Figure 2.—Limestone Quarry.



Figure 3.—General View of Hill.

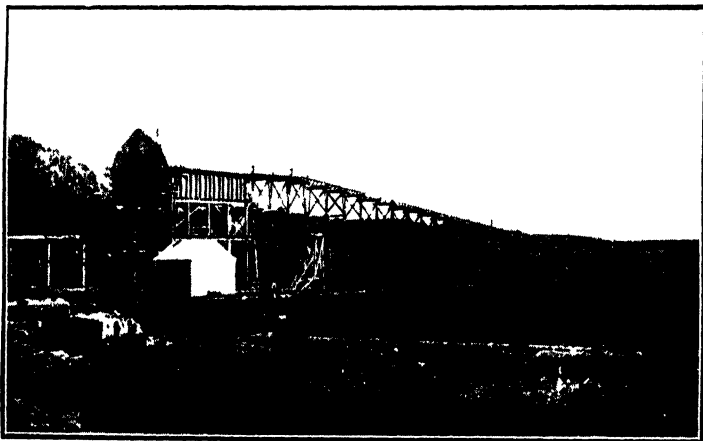


Figure 4.—Coal Bins at Coke Ovens.



Figure 5 —Coke Ovens

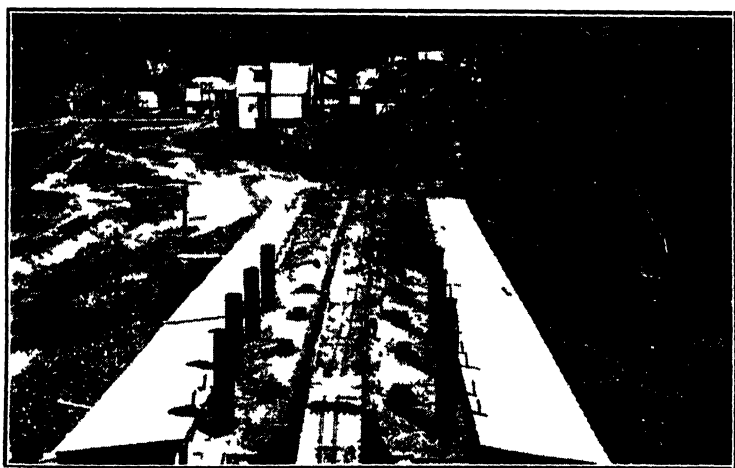


Figure 6—Top of Coke Ovens with 6 ton Charging Truck

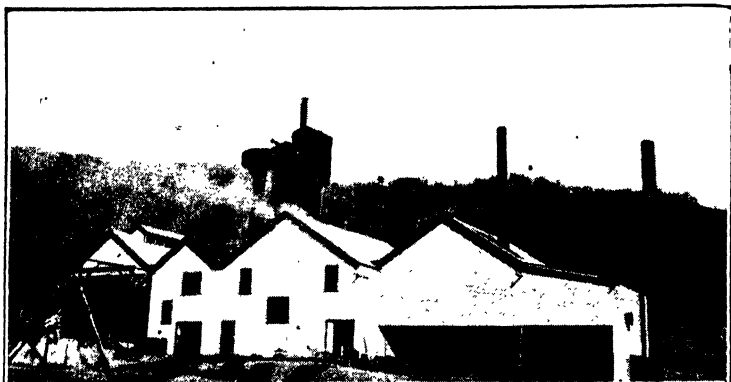


Figure 7.—Blast Furnace, Cast House Engine Room, and Boiler House.

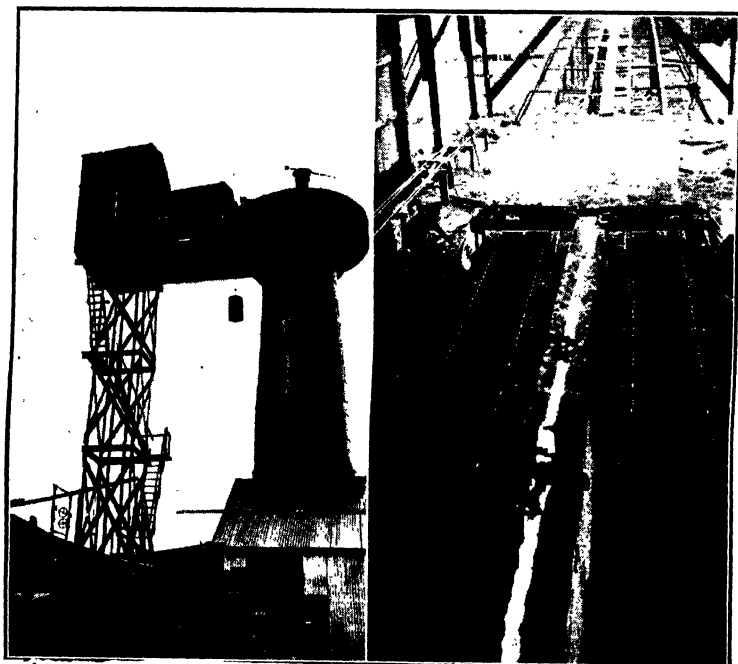


Figure 8.—Blast Furnace and Hydraulic Lift.

Figure 9.—Metal flowing into Cast Iron Moulds.



Figure 10 —Pig Iron being discharged from Cast Iron Mould into stock yard



Figure 11 —The Wharf and Bins

CLAY RESOURCES OF NEW ZEALAND.

By W. DONOVAN, Dominion Laboratory.

Although the clay industries are represented in New Zealand by sixty-nine brick, tile, and pottery works, employing in the year 1923-24 1150 persons, and producing goods to the value of almost £600,000 per annum, comparatively little has been written concerning our national resources of clay. Information regarding the extent and probable value of clay deposits in various districts may be found in the bulletins of the Geological Survey, covering the districts that have been examined. When the whole of the country has been surveyed the bulletins will contain complete and reliable data of all our clays, but at the present time large areas are still untouched. A paper published in 1924 as an appendix to the fifty-seventh annual report of the Dominion Laboratory gives analyses and results of firing tests of clays received over a period of years, but does not indicate the extent of the deposit of any clay examined.

In that paper (prepared by the writer) the clays are classified according to their chemical composition; in the present one the types of clay recognised in other countries are briefly described and their New Zealand occurrences indicated. The types considered are kaolin or china clay, ball clay, pottery clay, fire clay, terracotta, brick clays.

KAOLIN.

Kaolin, chemically, is composed almost entirely of kaolinite, a hydrated aluminium silicate $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$. The term is usually applied to a residual or primary clay, formed in situ by the decomposition of granitic rock. It is very refractory, and the plasticity is low. Washing is almost always essential to obtain the requisite purity, the

product, which is pure white after burning, being known as "china clay." Of true residual kaolin no deposit has, to my knowledge, yet been reported in New Zealand. There are, however, some white sedimentary clays of the same chemical composition. They are somewhat higher in iron content and also in titanium, are more plastic, and have a higher shrinkage on burning. Clay from Kaeo Road (Waimate North), from Kaurihohore, and from Otorohanga appears to be of this type. The mineral composition calculated from the complete chemical analysis, following the method described in the paper referred to, was as follows:

		Kaeo Road.	Kauri- hohore.	Otorohanga.
Felspars	... ..	2.31	5.14	4.51
Quartz	... ..	nil.	nil.	8.20
Limonite	... ..	0.80	1.10	2.37
Kaolinite	... ..	94.44	91.86	81.01
Minor constituents		2.45	1.90	3.91
		100.00	100.00	100.00

FIRECLAYS.

These are plastic clays, usually containing from 50 to 70 per cent. of silica and 20 to 30 per cent. of alumina. Other constituents, such as lime and alkalis, are present only in small amounts. The mineral composition would be kaolinite 40 to 60 per cent., quartz 30 to 45 per cent., felspars less than 5 per cent., limonite less than 3 per cent. The essential property is ability to withstand a high temperature without softening.

In Great Britain a No. 2 grade fireclay must show no signs of fusion when heated to 1580 degrees C., a No. 1 grade must resist a temperature of 1670 degrees C. China clays and kaolins would withstand such temperatures, but are not sufficiently plastic and are unnecessarily pure, as the colour of fireclay is usually unimportant. The clays of the Waikato coalfield vitrify at from 1300 degrees to 1400 degrees C., but do not soften at 1610 degrees C., the highest temperature attainable in the laboratory furnace. Equally refractory clay is found at Onakaka.

Clays from Whangarei, Brunner, and other of our coal-fields are successfully used in the manufacture of fire bricks and gas retorts, but have not been tested at the Dominion Laboratory, and no information is available as to their composition.

The fireclays of the Reefton and Greymouth fields have a rather unusual composition. They contain considerable amounts of alkalis, and chemical analysis alone would indicate that they are not refractory. The alkalis are, however, present not as felspar, which is readily fusible, but as mica, and although some of them vitrify at from 1100 to 1200 degrees C. they do not soften at 1580 degrees C. They could therefore be used either as pottery clays or as refractories. Those examined comprised clay from Baddeley's Mine, State Mine Reserve, Dunnollie, Charleston, Addisons, Dobson Mine, Greymouth.

BALL CLAYS.

In chemical composition ball clays are very similar to kaolin, being composed chiefly of kaolinite, but they differ in their high plasticity and strong bonding power. They burn to a white colour, vitrify readily, do not soften at high temperatures, and may be used as a bond for refractory ware. Their principal use, however, is as the foundation material in the manufacture of all kinds of earthenware. A clay from New Plymouth of calculated mineral composition, kaolinite 88.8, felspars 7.3, limonite 1.5, minor constituents 2.4 per cent., is a clay of this type.

It is possible that clays described in the next paragraph as pottery clays would also be classed by some under this head.

POTTERY CLAYS.

The best pottery is usually made from a carefully prepared blend of clay, with felspar, ground flint, and sometimes bone ash. For example, china clay may be mixed with felspar, which assists fusion and increases the density of the ware; with flint, to reduce shrinkage; and bone ash, to impart translucency. Similarly, ball clay may be mixed with flint, china clay, and felspar.

Until recently no deposit of felspar suitable for use in pottery industries was known in New Zealand, but Dr Henderson, of the Geological Survey, has located on the Baton

Saddle Road, Nelson, a mass of decomposed granite, which on washing yields 40 per cent. of clay passing 200 mesh, and having the following composition:—

Felspars	...	...	...	74.4
Kaolinite	...	...	...	10.6
Quartz	...	...	...	12.9
Limonite	...	...	...	1.3
Minor constituents	...	...	...	0.8

100.0

This material could replace felspar in the manufacture of porcelain. Another clay found at Puhipuhi of excellent colour and containing 55 per cent. of felspars could be similarly used.

Flint has not been found in marketable form in New Zealand, but the glass sands from Mount Somers and from Takaka, which contain over 99 per cent. of silica and less than .1 per cent. of iron oxide, could doubtless be ground and used instead of flint. An exceedingly fine siliceous sand which occurs at Silverdale, near Auckland, should be equally suitable, and would not require grinding, as over 97 per cent. will pass a 200 mesh. The silica content is 97.15 per cent. and iron oxide .23 per cent.

There are, however, some white clays which are natural blends of felspar, quartz, and kaolinite in proportions suited for the production of good porcelainware at moderate heat. Such are found near Whangarei (derived from the trachyte rocks), at Tadmor, and at Wyndham.

At Glen Massey a white clay is found which, though deficient in fluxing constituents, yet gives hard, dense porcelain of good colour when fired at 1340 degrees C.

The mineral composition of these clays is:—

	Whangarei (washed).	Tadmor (washed).	Wyndham.	Glen Massey.
Felspars	15.66	25.70	26.37	5.29
Quartz	45.58	5.73	38.65	35.39
Limonite	1.09	1.37	1.86	1.67
Kaolinite	36.74	65.90	28.08	55.33
Minor constituents (by difference)	0.93	1.30	5.04	2.32
	100.00	100.00	100.00	100.00

A gritty clay, at the base of the Tertiary deposits, Baton Saddle Road, from the same locality as the felspathic clay previously described, contains 50 per cent. of material passing a 200 mesh sieve, which has the following composition :

Felspars	...	...	...	42.48
Quartz	...	...	...	42.44
Kaolinite	...	...	...	12.96
Limonite	...	...	...	1.27
Minor constituents	...			0.85

100.00

This gives a dense white porcelain on burning.

All these yield porcelain of good quantity, and would be suited for the manufacture of electric insulators and fittings, for which there is a good demand, also for sanitary ware.

Insulators of very good quality are at present being manufactured at Temuka.

Stoneware clays giving a coloured body, varying from cream to brown according principally to the percentage of iron oxide present, are found at Kawa Kawa, Whangarei, Fairdown, Giles Creek, Empire Colliery (Reefton), Waikaia, Terrace Colliery (Balfour).

BRICK CLAYS.

While kaolin and porcelain clays are valuable and essential for the full development of ceramic industries, the clays most essential for New Zealand, at its present stage of development, are those suitable for the manufacture of building bricks, sewer pipes, and roofing tiles. Even in older countries bricks, pipes, and tiles outweigh in value all other ceramic products.

A brick clay usually contains from 30 to 40 per cent. of clay substance. A certain proportion of fluxes is necessary to give a bond at comparatively low temperatures. The presence of iron is desirable, to impart a red colour. The clays found at Taumarunui, Wellington, and Abbotsford may be taken as typical. The mineral composition of these is:—

		Taumarunui.	Wellington.	Abbotsford.
Felspars	... ..	35.98	21.62	30.07
Quartz	... ..	22.14	38.81	27.47
Limonite	... ..	9.28	6.32	4.33
Clay substance	... ..	32.60	33.25	38.13
		100.00	100.00	100.00

Bricks may be made from almost any clay, the properties being modified if necessary by a mixture with other clays, with sand, or with grog. A practical test has evidently been considered sufficient in most cases, for few of the many clays successfully used for manufacture of bricks have been analysed in the Dominion Laboratory.

Tiles may be made from brick clays of fine texture.

A terracotta clay is one of fine texture, giving a fine dense surface, containing sufficient fluxes to make it weather resistant without fusion, of small shrinkage, and of pleasing colour when fired. One such clay is found at the head waters of the Mangawhero stream, Otorohanga.

CLAY FOR CEMENT MAKING.

Portland cement is prepared by calcining an intimate mixture of 70 per cent. limestone and 30 per cent. of clay, usual siliceous. Of late years Alumina cement has been developed, and is much in demand because of its quick hardening properties. The difference in the two types is shown by analysis:—

	Portland cement.	Alumina cement.
Silica (SiO_2)	21.53	9.18
Alumina (Al_2O_3)	7.56	40.50
Iron oxide (Fe_2O_3)	5.02	9.77
Titanium dioxide (TiO_2)	undet.	1.60
Lime (CaO)	61.91	38.00
Magnesia (MgO)	1.20	0.54
Alkalis (soda and potash)	0.91	0.41
Sulphur trioxide (SO_3)	0.95	undet.
Water and carbon	0.92	undet.
	100.00	100.00

Alumina cement could therefore be produced by calcining a mixture containing 60 per cent. limestone and 40 per cent. of highly aluminous clay or bauxite. While no bauxite has been discovered in New Zealand, there are some highly aluminous clays in the Whangarei district. One from Crawford's farm, Ruatangata, contains 45 per cent. of alumina, calculated on the clay dried at 100 degrees C. Another from the north side of Maungarei Hill contains 41 per cent. These are richer in alumina than kaolin, for if all the silica present is calculated to kaolinite there remains an excess of alumina of 18 and 10 per cent. respectively.

It would be interesting to ascertain whether their use in Portland cement mixtures would result in an improved cement.

SUMMARY.

It is evident that New Zealand possesses abundant resources of clay and many varieties, and the clay industries will become increasingly important as the country develops.

With the depletion of our timber reserves the output of building bricks must increase in the near future.

Hydro-electric development has created a demand for electric insulators and porcelain fittings for the manufacture of which we have several suitable clays.

We have the raw material for the production of sanitary ware of good quality.

When in the future the local demand is sufficient to warrant the establishment of pottery works, suitable high-grade clay will be available. Until that time arrives the possibilities of an export trade might be considered.

ACKNOWLEDGMENTS.

The writer would acknowledge his indebtedness to "The Chemistry and Physics of Clays" and "The National History of Clay," both by A. B. Searle, for information on the types of clay usually recognised, and also to Dr J. S. MacLaurin, Dominion Analyst, for permission to draw on the records of the Dominion Laboratory for material for this paper.

THE TREND OF GOLD MINING IN NEW ZEALAND.

By ROBERT GILKISON.

Author of "The Law of Gold Mining in New Zealand."

More than 64 years have passed since the startling news of the discovery of payable gold in Gabriel's Gully, Tuapeka, went ringing its way throughout New Zealand, Australia, and the whole world. Sixty-four years have gone since the issue of the first regulations dealing with the taking up of Crown Lands as mining claims. During these years the methods of winning gold have changed, and so also has the legislation dealing with the acquiring and holding of gold mining privileges.

The first years were the era of the cradle and the long tom, the shovel and the tin dish. Then came the days of water races and sluicing, followed by the introduction of hydraulic elevating and sluicing plants.

In the seventies the mountains of the interior were explored for reefs. In the eighties and nineties dredges developed from machinery driven by current wheels to elaborate instruments receiving motive power from steam or electricity.

At the present time mining looks more than ever before to capital for assistance. The luscious plums have been mostly picked out, and it is only by working with the most modern machinery and on a large scale that good returns can be expected.

In the same way has mining legislation moved. The small one-man claims of 100 feet by 100 feet which were the rule in 1862 are now no more. The most valuable ground is mostly held under special claim grants, which are virtually leases for gold mining purposes.

For many years a rule was recognised that no claim should include more than one mile of a river or more than 100 acres, but the Act of 1905 allowed three miles to be granted for a dredge and two miles for a hydraulic elevating claim. In 1924, recognising the altered conditions, Parliament provided that a dredging or sluicing claim may be granted of any shape, but not exceeding eight miles in length or 1200 acres in area in any case where the land had been previously held as a dredging or alluvial claim and had been abandoned.

In 1924 Parliament further recognised that larger claims must be granted where the depth of a claim is so great that special machinery is required to work it. It was then provided that where the ground to be dredged is of a depth not exceeding a depth to be approved by the Minister, the claim may be eight miles long or 1200 acres in extent.

These are very great changes, which in the earlier days would have met with the keenest opposition from individual diggers. To-day, however, it is generally recognised to be essential to encourage expenditure of capital to carry on such operations as referred to. Such expenditure will be largely distributed amongst the workmen, who, whether the venture pays or not, will be sure of their wages for many years.

The great success of the Rimu dredge on the West Coast will, no doubt, stimulate the expenditure of capital on suitable claims. Without such encouragement as we have mentioned, investors could not be expected to build the large and heavy dredges which are required.

Looking back on the mining boom at the beginning of the century, I am inclined to the view that great losses were caused then by unsuitable and unwise legislation. At that time no claim could exceed a mile in length, although the river might be so narrow that a mile would contain only a few acres of dredgeable ground. The Minister declared that he was against granting protection, so the holders of claims pushed on their dredge building with great haste. Had wiser counsels prevailed, only one-third of the dredges would have been built, and these might have had a long, payable life. Unfortunately, partly as a result of bad legislation, partly due to the excited feelings of the time,

every claim was floated into a company, and every company built or tried to build a dredge. Some dredges were seized by creditors before completion, some never reached the claims they were built for; most of those that did start had a heavy load of debt upon them even at the beginning. Had the claims been larger then there would have been much less mortality.

The law was not altered to allow three miles to be held until too late for most of the companies.

FORFEITURE AND ABANDONMENT.

From the earliest days the Mining Acts recognised that in order to maintain a title to any claim or right, work must be carried on upon or in connection with the same with diligence, and the conditions imposed by the Act must be complied with.

The old Acts had many defects, which, however, have sometimes been remedied by legislation and sometimes by judge made law—that is, a series of decisions bearing on and interpreting a point left at large by the Statute. The Warden from the beginning was given power to impose a fine in lieu of forfeiture but for many years the Wardens used this power almost at random. The higher courts have, in the course of years, by many decisions laid down the general principles which should guide a court in inflicting a fine instead of declaring forfeiture, so that this branch of the law may now be considered clear and well settled.

Generally the courts will substitute a fine in lieu of forfeiture when early neglect has been followed by zealous, continuous work, or when claim holders have fallen into merely technical errors, but not where there has been aggravated neglect. With regard to races the courts have held that the law should be very strictly enforced, as the locking up of a race may injure the whole district.

Where defendants have no intention of again using a race for mining, but desire a change of purpose in order to permit of its use for irrigation purposes, the Warden should not exercise his discretion in imposing a fine, but should decree forfeiture.

It is much better that the courts in actual cases should lay down general principles on which they will act in substituting a fine. Had Parliament attempted to put these principles into statutory form the tendency would have been to limit the discretion by cast-iron rules. No two cases are quite alike, and to put into statutory form the effect of all the rulings on the subject would be exceedingly difficult, and would limit the discretion of the court and not allow for the constant change of conditions which goes on in mining matters.

EXTENSION OF POWER OF THE MINISTER.

Perhaps one of the most notable changes in the law is the extending of the powers of the Minister under the Mining Act. Formerly the Minister's consent to a special claim grant was little more than a matter of form. Now the Minister will not consent except under stringent conditions.

The following is the substance of the conditions which have recently been imposed by the Minister on the license for a small special alluvial claim on the banks of the Kawarau River:—

1. Applicant to deposit £100 as security that he will within eighteen months erect a suitable dredge on the claim.
2. Licensee not to assign except with the Minister's consent.
3. Any tribute agreement to be submitted to the Minister for approval.*
4. Before promoting any company to work the claim, prospectus to be submitted for Minister's consent, but prospectus must not state it has been amended or amplified by or submitted to the Minister.

The Minister's consent is necessary now amongst others in all the following cases:—

Land outside a mining district.

Land over 30 acres.

Land under sea or foreshore.

Land in Otago for ordinary alluvial claim, extended alluvial claim, or hydraulic elevating claim.

Dam or water race for more than 20 heads.

Water race taking water from a mining district to outside a mining district. (Sec. 105, 08, 4/11.)

Change of purpose of water held under water race license. (S. 117/08.)

The consent of the Minister generally means the consent of the Department.

There is no provision for appearance of objectors and applicants before the Minister or for any notice being given when he will consider a matter. I take it that in important matters the Minister will sit as a judge and be guided by the evidence put before him and the Warden's report, and the reports of his own officers, yet in giving his decision he may give no reasons, and there is no appeal from his decisions except in Parliament.

I am inclined to think this extension of the Minister's powers a very dangerous one. We may find in the future a case where an application is opposed before the Warden, where evidence is fully taken, counsel heard, and the Warden's decision recorded. Later the same application may come before the Minister, who cannot see or hear the witnesses, but who for undivulged reasons may refuse what the Warden approved of, or vice versa.

I believe the present Minister of Mines has used his powers in a most exemplary way, but another Minister who is not so conscientious may give decisions which conflict with the best interests of mining. As stated, the only check upon the Minister are the debates and actions of Parliament. Applications under the Mining Acts should be dealt with in a judicial manner only, and the noisy and unrestrained clash of a party debate in the House is far removed from the impartiality and stillness of a court of law.

My opinion is, all disputed matters should be decided by the Warden, subject to appeal. If the Mining Department desires to object to an application it should do so, and the evidence of the department's officers could then be taken in open court, when due weight could be attached to their statements and opinions. This would relieve the Minister of being expected to act in such cases. The Warden and the Appeal Court are surely to be trusted absolutely.

The imposition of such conditions as the Minister has lately been imposing on special claim grants would be far better effected either by statute or by regulation.

WATER RACES.

The history of granting of water rights has been a most interesting one. These have been granted as indefeasible easements, which materially affect the common law rights of riparian proprietors. Indeed, in many respects the powers of a race licensee are superior to those of an owner of the land through which a stream flows. He may take and carry off water from one stream to another watershed (if so allowed by his license). His rights are only limited by the Mining Act and the conditions on which he holds such rights; the law of forfeiture and abandonment provides a necessary check upon his powers.

Originally in Otago water was not granted indiscriminately to the first applicant. The quantity which an applicant for a race was entitled to was limited to:—One or two miners, one head; four or more miners, two heads; and so on at the rate of one head for every additional three miners.

In 1865 water was granted at 5s a head to those desiring it. Since then the rental of 5s a head has been done away with, also the limitation to number of men employed. The water rights of Otago are generally held for a term of 42 years without rental and subject only to the condition of the race being kept in proper order and the whole of the water taken and used for the purpose for which it was granted.

It was held under the former Acts that a race for mining purposes could not be exchanged for a water right for irrigation, but Section 128 of the Act of 1905 first gave this power, and Section 5 of an Amendment Act of 1903

a change of purpose to be granted subject to the Minister's consent.

Latterly as ground held for mining purposes has come to an end there has been an endeavour in Central Otago to obtain a change of purpose for many valuable old mining races. If such a change is granted the right becomes at once very valuable, for there is a very general and increasing demand for water for irrigation in the district.

In most cases the Minister has refused to consent to such applications unless special ground for doing so were shown, because to do so would be to grant the race owner something he never had before and to change his right into one with a monopoly value.

Something should be said here as to the priority of water rights. The law is, the first right must be fully supplied before the second, the second before the third, and so on. Each race should be gauged at the head with a gauge box of regulation size according to the quantity of water granted. Where there are a number of rights from the same river, and the same race has both superior and inferior rights, to carry on gauging becomes a most difficult and complicated operation. However, in the past there have been comparatively few disputes between right holders as to gauging because the owners learn to judge the water by the eye, and, knowing their own and their neighbours' rights, see that the prior rights are supplied without requiring legal notice or legal gauging.

A good many years ago a Warden who saw that immense quantities of water were being applied for from the Otago rivers and who recognised that the land question of Central Otago is linked up with that of water supply, attempted to make some very stringent conditions to apply to all races.

Great complaints were made, and the conditions, which were too stringent and lacked elasticity to meet deserving cases, were abandoned.

However, now the Minister's consent is required to every water race for over 20 heads, and the Minister will no doubt lay down conditions suitable to each case.

The objections raised before as to the Ministerial consent to claims are not so strong where water grants are concerned, because water is an exceedingly valuable public property and ought not to be granted away to every person who comes along and asks for it. Water is so very scarce and valuable in Central Otago that it should only be granted subject to very strict limitations and conditions. Regulations could be drawn up and promulgated which would lay down the sole conditions on which water rights may be granted or leased.

Sometimes in the past a Warden who has made a special study of the water requirements of a district has intimated from the Bench the manner in which he proposes to deal with future applications from certain streams, and while he remains in the district gives effect to his intimation. A change is made, and a new Warden arrives who knows nothing of the special conditions, so there is thus a lack of consistency and continuity in the mode of dealing with applications. There have been cases where for 20 years Wardens have ruled a stream is over-granted and no more rights should be created, and yet a new Warden has come on the scene and undone all the good work of the previous Warden by proceeding to issue new grants. In such cases either a serious injustice was done to the earlier applicants who were refused, or a more serious injustice to the community and the earlier right holders by granting the later rights.

The reference of more important matters for the Minister's consent will help to provide continuity and consistency in these matters at least, and will enable a settled policy to be carried out

KAWARAU DAM.

A large undertaking was entered on in Otago in 1922 when a commencement was made with the erection of a dam at the point where the Kawarau River makes its exit from Lake Wakatipu. This dam, when erected, is intended to impound the waters of the lake for a time, and so leave the river dry and give an opportunity of working the bed for the rich gold believed to be there.

The company which is responsible for the dam also holds large claims on the river, which are subdivided and sub-let on terms to various companies and partnerships.

The inception of this new work has rendered necessary certain new provisions in the law. In the first place it is now provided that any license for a dam requires the Minister's consent. It is right and proper that a large undertaking like the Kawarau Dam should not be entered upon without the Minister's approval, and although the law did not require it at the time the Kawarau Dam was applied for, the Warden did not grant it without the approval of the Minister.

Had the law required the Minister's consent some years ago, when hundreds of alluvial miners were continually applying for small dams of an acre or two, this restriction would have been very burdensome to the department and very annoying to the mining community.

Section 4 of the Mining Amendment, 1924, was evidently intended for such cases as the Kawareau subdivisions. Clause 1 provides that no dredging claim in the bed of a river in respect of which a tribute agreement has been made, shall be forfeited without the consent of the Minister.

Clause 2 provides that every such dredging claim shall be deemed to be protected when owing to the depth of the water of the river it is impracticable to work the claim efficiently.

In the future any person desiring to obtain a decree of forfeiture of any claim coming under above section must first proceed in the Warden's Court, and, if necessary, fight out any appeal to a Higher Court, and when successful there must then apply to the Minister for his consent, when, no doubt, in important matters, a further legal battle will take place.

The Act has made no attempt to state what matters the Minister may take into effect in giving his decision, and it would appear the ruling in each case will depend, as was said years ago of cases in Courts of Chancery, on the length of the Lord Chancellor's foot.

The object of this section, no doubt, was to render as invulnerable as possible the titles for these tribute claims, and in consideration of the vast expenditure of capital on the dam and other plant necessary it is reasonable that some special protection should be afforded these claims. Yet it appears to the writer that the Minister may find himself under this section in a very awkward position. The Warden sees the claim and hears the witnesses, and brings the whole of his local knowledge and experience to bear on the matter. In deciding whether to decree forfeiture or to impose a fine, he has the advantage of the decisions of the courts in the last 50 years.

If either side is dissatisfied an appeal will lie on either law or fact, or both. To require a still further hearing before the Minister seems superfluous, and on what lines he will act it is at present impossible to say. I think when the law required such cases to go to the Minister it should have stated clearly the Ministerial duty.

Some 30 or 40 years ago the goldfields vote was a powerful one in Parliament, and a number of members were representatives of districts which were all gold-producing. When men like Richard Seddon and Vincent Pyke sat in the House the miners never lacked a skilled advocate or a warm friend, and the support of the gold mining vote was sought by Cabinets and Ministers. Now the goldfields districts are only small corners of much larger districts, and very few members take much interest in or even understand the mining law. The drafting of the mining laws seems to be now largely left to the Mining Department. This, combined with the modern tendency to leave all difficult details to be dealt with by Cabinet, explains the fact that more is now left to the Minister's discretion.

IRRIGATION.

We have already referred to the tendency to use water for irrigation instead of gold mining and to the powers of the Warden and Minister to sanction a change of purpose for which a race is held. These changes have become more necessary because of the altered state of affairs. The independent gold miners of 60 years ago who opened up Central Otago with their shovels and tin dishes have in their turn moved on; in their place we have the farmers, graziers, and orchardists. Some very interesting particulars as to the beginning of irrigation in Central Otago will be found in the judgment of Judge Wilson Gray in the case of *Feraud v. Holt*, heard by him at Clyde in 1871. He says: "For a time irrigation was but little practised in the valley, and the rights of the race holder and of the people of Clyde to whom he supplied water seemed to be growing solid with length of enjoyment; but when Feraud came into the valley, being more familiar with the value of irrigation than those who had preceded him, and his land being poor and shallow, he

began to use more water. The hotter and drier the weather the more water was needed by either party and the less to be had in the creek."

Years have rolled on. Mining has gradually gone back and irrigation has come on. In many ways the laws have been varied to suit the new conditions.

County Councils are now empowered to hold and acquire races. This power has been used with great advantage in many cases.

In the early days the Crown purchased and held many water races in the goldfields from which it sold water to the miners. This practice has gradually gone out. Now under the Public Water Acts the Crown can make and hold races and charge the settlers for the use of the water. Very large sums have been expended on reservoirs and water races for irrigation purposes.

It would be well to see the power of local bodies or of small water trusts more and more expanded in the direction of acquiring and holding water rights for the benefit of their districts.

However, these matters only come up incidentally under the head of mining legislation, being now most satisfactorily dealt with under separate laws.

We may here note an experiment which was made in 1913, when special provision was made by statute for a company formed for irrigation and subdivision of land in Vincent County. That company, the Cromwell Development Company, had made arrangements at great expense to pump water from the Kawarau, and the Governor was authorised to sell to it Crown lands at a price to be fixed by the Land Board, the company undertaking to irrigate, to subdivide, and offer the land for sale or lease by auction, tender, or contract. That company has spent large sums under the powers conferred on it, and has converted into beautiful orchards many acres of poor-looking, gravelly flats.

Although the water is used for irrigation pure and simple it is deemed to be for "mining purposes" under the Mining Act, 1908 by Section 6 Sub-section (d) of the Water Supply Amendment, 1913.

CONCLUSION.

On the whole Parliament has endeavoured to provide legislation suitable to altered conditions. Titles are now more secure to a bona fide holder. The conditions subject to which they are held, are more clearly defined. Greater areas can be held provided sufficient expenditure of capital is guaranteed. Yet the public interests are more closely guarded than ever, and mere speculative applications are discouraged.

While I have commented on the necessity of obtaining the Minister's consent in such cases as a forfeiture suit, I freely admit that a reference of an application for a new privilege to the Minister will often furnish an admirable safeguard against giving away the national assets, which in the past have sometimes been too freely granted. Moreover, the necessity of satisfying the Minister will also tend towards a system of truer consistency than prevailed in the past.

The mining law has also expanded to meet such cases as the demand for irrigation, the growth of hydraulic sluicing, the sudden expansion of dredging, the reef-hunting of the seventies and eighties, the introduction of deep sinking, and lastly the scheme of the great Kawarau Dam.

ON PROSPECTING AND THE REVIVAL OF METAL MINING IN NEW ZEALAND.

By J. F. DOWNEY, Inspector of Mines.

The two subjects forming the title of this paper are so closely associated and so difficult to deal with separately that the writer has thought it well to treat them as one; and as anything to be said with regard to them can scarcely fail to be of interest to a number of those present no special apology seems called for in offering some few thoughts concerning them; indeed, it would appear as though someone were to blame if such an opportunity of awaking public interest in them were allowed to pass by. Metalliferous mining in the Dominion has fallen into a decidedly backward condition, and prospecting effort has almost entirely ceased, and if the position with regard to them is to improve some remedial action seems called for. The suggestions put forward herein may not present a solution to the problems the industry is faced with, but it is not unreasonable to hope that from a discussion of the position some ideas and advice may be forthcoming that will materially help to bring about a happier condition of affairs.

Coal-mining has made consistent progress in New Zealand, and is just now probably more active and prosperous than at any other period, but it is common knowledge that metalliferous mining has for some years been seriously declining in importance. In 1905 there were employed at this latter class of mining some 9362 men, as against 3269 in coal-mining, whereas in 1924 the figures for the respective branches were practically in the obverse order; and the output from each has varied in proportion. The position thus brought about has, naturally, been a source of grave anxiety to all interested in metalliferous mining, for the

falling off has been so marked from year to year that it has become evident unless a change for the better soon takes place this branch of the industry seems doomed to extinction.

As far as the base metals are concerned, the Dominion has not been at any time more than a small producer. Of the total of £94,486,980 set down as the value of all metals or minerals other than coal entered for export to the end of 1923, no less than £90,863,040 represented that of gold. Copper, chrome, antimony, manganese, and tungsten ores have been mined to some extent, but the total production of them all has only been valued at £474,395. Practically no copper or chrome ores have been mined since 1888. Manganese ceased to be mined in 1903, and antimony in 1908. The tungsten ores were largely worked during the period of the recent war, but when the latter came to an end the market for the mineral failed, and further production was abandoned. The production of gold, which had gone along with only unimportant fluctuations in annual output from 1861 onwards, seems to have reached its high-water mark in the period 1903-09, the average yearly output for the seven years being valued at £2,062,212. The year 1906 showed the largest yield, with gold to the value of £2,270,904. Unfortunately, the high hopes engendered by the very successful operations of this period were not destined to be realised. Instead of the encouraging yields heralding the coming of a long run of prosperity, they marked the turning of a tide in gold-mining, that may be said to have been on the ebb ever since. In 1923 the total value of the gold recovered from all sources had shrunk to £698,583.

There can be no doubt but that the chief cause of this retrogression has been the gradual exhaustion of the older goldfields, with no new discoveries coming along of sufficient importance to fully replace them. Other contributing factors have been the dying out of the old-time prospector, the drifting away of the younger generation to other lines of work offering surer return and perhaps a more comfortable mode of life, the neglect of the mining public to make any well-directed or energetic efforts to investigate the lesser known parts of the Dominion, and, to some extent, the failure in the past to keep as full data regarding our mines, or to make as close geological observation of them as was

advisable. Lack of general knowledge as to minerals on the part of our prospectors has probably also helped, and the coming of the Great War undoubtedly hurried the downward trend of the industry not merely by depleting it of its best men, but by loading it with an intolerable increase in the cost of labour and supplies without any corresponding increase being forthcoming in the value received for its product. Between 1914 and 1918 the number of men engaged dwindled from 4470 to 2582, and by 1920 had further shrunk to 1930. Most of the active young gold miners enlisted, many paid the supreme sacrifice, and of those who returned only a small percentage resumed their old calling.

The failure of the returned soldiers to go back to mining was attributable to some degree to ill-health, and a desire for change resulting from war experiences; but the inability to make many small mines pay under the costlier working conditions prevailing was perhaps more responsible for it. Another thing that probably had a good deal to do with the decline of metal mining was the amount of "wild-cat" flotation indulged in both before and since the start of the war. The dredging boom that occurred in the years following 1890 unquestionably cost metalliferous mining many supporters, and the number of ill-fated and ill-advised reefing and other flotations that have since been worked off on the public did not help to improve the situation. Large numbers of well-intentioned speculators were tempted by specious tales into ventures that had no chance of success, with the result that they lost their money and turned in disgust from the whole game.

However that may be, the fact remains that the position of metal mining in this country is now palpably most unhealthy, and in reviewing it a number of questions suggest themselves, the first of which is as to whether under any conditions the outlook of the industry in the Dominion offers any promise of material improvement. Even amongst well-informed mining men the belief is not uncommon that sufficient work has already been done to show that the country is clearly not destined to be a future producer of minerals to any important extent, and that thus further effort to revive mining is not warranted. A certain amount of justification for the holding of this opinion may be found.

As far as the geological survey of the country has been carried out, it has not shown the Dominion to have many unexploited metalliferous deposits likely to prove of very great economic importance. Nearly all the valuable minerals are in evidence, but they do not occur in sufficient quantity. It must be admitted, too, that much prospecting has been done with but indifferent results. The concession may also be made that as far as gold, which up to the present has provided our main supply of mineral wealth, is concerned the possibility or probability of finding it in the future in quantities even approaching those of the past are remote. The working of some of our alluvial flats by big American type dredges and new reefing finds, such as the recent rather promising one at the Alexander River in Inangahua County, made from time to time, may tend to restore gold-mining to some extent, but in a general way it may be said that the possibilities of the Dominion as far as this particular metal is concerned have been fairly well tried out, and only the confirmed optimist could entertain the belief that it is likely to be won again in such quantity as formerly. Nevertheless, New Zealand still has possibilities as a mining country. Despite the fact that the old-time hardy prospector was not easily daunted, and pushed his way into the most inhospitable regions, indifferent to all kinds of hardship, there still remain large mineral-bearing tracts to which he either did not penetrate at all or to which, owing to difficulty of access or of maintaining supplies, he was only able to give the most cursory examination. Again, the Geological Survey, although it has already done much valuable work, has only as yet examined in detail about one-seventh of the Dominion, and among the parts it has not surveyed are some of those in which the early prospector found it most difficult to carry on his investigations. Apart from this, it cannot be said that even those portions of the mineral regions of the country that have been gone over most frequently by the so-called prospector of the past have been nearly so fully or carefully examined as they should be, for the simple reason that they have been searched for one mineral only.

The independent prospector of the Dominion's earlier mining days may have been more thorough in his methods, but there seems no strong reason for thinking him a closer or keener investigator than his modern successor; and as

far as the latter is concerned one has not to seek long to discover how far his vigilance went. An inspection of about 400 subsidy files in the offices of the Mines Department at Reefton shows that without exception every application for assistance was made for the specific purpose of enabling the men to search for gold. This may have been accounted for by the fact that the financial reward to the finder from the location in payable quantities of the precious metal was quicker and surer than from the discovery of less valuable minerals; but it is much to be feared that the search for this metal to the exclusion of all others is more reliably explained by the assumption that the prospectors knew something of gold and its occurrence, but possessed little or no knowledge regarding other minerals. Close intercourse with many of our present-day prospectors has satisfied the writer that this conclusion may be accepted as correct.

It is remarkable how little the average individual who now takes on field prospecting knows of any mineral other than gold. Two really clever prospectors for gold, questioned recently as to their acquaintance with such minerals as scheelite, molybdenite, galena, cinnabar, wolfram, monazite, and cassiterite admitted that they knew nothing of any of them, and could not identify them. As these men are typical of scores of others, it may be readily understood how imperfect much of the past examination of the country's mineral areas is only too likely to have been. On top of this, when an attempt is being made to determine just to what extent past investigation has gone, the difficulty of making anything approaching a thorough examination, even under the most favourable conditions, of a very large portion of the Dominion must be understood. For the greater part our mining districts are heavily timbered, and the surface is thickly spread with a deposit of forest matter (pukau), to say nothing of a tangled mass of roots, undergrowth, etc., while over immense stretches slips and the action of frost and rain have deeply concealed the original rocks. In the West Coast district it is possible to travel over thousands of acres without seeing a natural exposure, and under circumstances such as these the imagination needs no forcing to realise how impossible thorough prospecting is. Much of the examination of this district has actually been done by the blind-stabbing method known as

“spearing”; that is to say, the men carrying out the work have gone through the bush armed with a spear, which they drove down here and there through the surface litter, trusting to luck to hit on reef below it. Only in cases where the spear seemed to strike something apparently solid enough to be quartz were the mattock and shovel brought into use.

Keeping all these facts in mind, it cannot thus be honestly claimed that the mining possibilities of the Dominion are exhausted. Where there is room for exploration there is room for discovery, and there is scarcely any gainsaying that in New Zealand there are still wide areas urgently in need of probing by the pick of the competent prospector.

If it be granted that the country still holds some promise of having a healthy mining future, the further questions then inevitably arise as, in the first place, to what chance there is of metal mining regaining something like its former vigour along what may be termed purely natural lines of development, and, in the second place, failing restoration in a normal way, what other means there are of promoting the desideratum.

It is greatly to be feared that if the industry is allowed to work out its own salvation along the lines now followed, there is not much to hope for in the future. Some measure of improvement on the present position will, without doubt, manifest itself in the exploitation of our deposits of such minerals as iron, asbestos, dolomite, and talc, none of which have figured to any extent up to the present in our production tables. There may also be an increase in the output of sulphur and mercury, and the working of limestones and building stones will unquestionably extend itself.

It is well known that the Dominion possesses valuable deposits of iron ore. At Onakaka, in Collingwood County, a company is just now completing a smelting plant, costing roughly about £130,000, to deal with one of these. During last year a trial run was made with this plant, then in an unfinished state, and 700 tons of pig-iron were produced and disposed of to ironfounders throughout the country, who tried it for their various requirements with satisfactory results. It was thus demonstrated that not merely was the

crude ore readily treated, but that the resultant blast furnace product was of a quality suitable for New Zealand needs. Should this venture succeed, as it certainly deserves to, its output should materially help to increase the value of our annual mineral production.

In other localities movements are also afoot to put to use deposits of dolomite and asbestos, of which important quantities are known to occur. The working of the minerals mentioned is almost certain to help metalliferous mining towards somewhat better days than it is now experiencing, but without a simultaneous improvement in the output of gold it is too much to hope for that such help will be sufficient to restore the industry to more than a modest approach to its former importance, and there seems no good reason for thinking that such increase in the recovery of the precious metal will eventuate without some special effort being made to induce it. Failing an improvement in gold-mining along normal lines, the only conclusion that can be arrived at is that, if metal mining is to be effectively revived, artificial stimulus of some kind must be employed.

How this is to be done is not so easy to say. A good many means suggest themselves, but the most reasonable way of doing it appears to be by initiating well-organised, systematic, and persistent prospecting efforts, from which not even the well-worked reefing fields should be altogether excluded. In each of our quartz-mining districts there are possibly mines now idle that deserve much further examination. At Reefton old mines such as the Globe-Progress and Kirwan's Reward may be referred to as instances. The stone that was mined from each of these unquestionably came from earth-blocks faulted from their original position, and in neither case was a downward continuation of the lode traced beyond the fault. It is possible that in mines such as these further work carried out on sound, scientific lines would locate the lost portions of the lodes, and give the properties a new lease of life.

To a more limited extent it may also be said that some of the old alluvial fields may answer kindly to similar capable investigation. To put the matter into other words, as thorough overhauling as circumstances permit of all the country's possible sources of metalliferous wealth should be made, so that we may know definitely, for better or worse,

just where we stand, and it is not too much to say that this should be done without unnecessary delay. The effort should at least be made while there still remains in the community some vestige of the old spirit that in former days prompted every man in the Dominion to try his hand at digging. The mining instinct is dying rapidly amongst us, and once it has been entirely stilled will be difficult to recall.

Any prospecting effort such as referred to would have to be of a comprehensive nature, and, naturally, include in its scope varied lines of operation. The further investigation of our already fairly well examined or more readily penetrable areas must, for instance, still be left largely in the hands of the independent prospector or the small unsupervised party, that of our own reefing fields must be entrusted to the trained scientific observer, while still other means must be adopted in testing the regions really difficult of access.

As far as the independent or small-party prospector is concerned, the writer is not inclined to trust greatly to his employment, at least along such lines as are now followed, to bring about any very striking change for the better. It must be admitted that the Dominion has to thank this type of investigator for such mining success as it has achieved, for to him it owes practically all the early mining discoveries, but his best work was done in days when he entered on his task wholly for sheer love of it, and in the hope of winning quickly through to fortune, troubling his head not at all over such matters as wages or subsidies. Since the introduction, however, of subsidised prospecting, the results of this class of work cannot be considered satisfactory. It is claimed that several fairly important discoveries, such as that of the Blackwater reef and the Alexander River reefs in the Reefton district, were the outcome of Government assistance timely given, but even allowing for these the work carried out during the last 17 or 18 years by means of aid under the Prospecting Regulations has been, to say the least, disappointing. The greater part of the exploration done during this period has been by small parties, seldom consisting of more than two men, and a considerable amount of assistance has been given it. What sum the Government, through the Mines Department, actually granted throughout the whole

Dominion for this small-party work, the writer has no ready means at hand of determining, but in the West Coast district alone it amounted to over £6000, a very large portion of which was spent in the more accessible mining areas and on actual field prospecting. If in these areas little good resulted from the efforts put forth, it may be readily understood how futile they were in the more difficult ones, and it is not hard to see how inevitable this was

Take the case of a party of two men going into the Sounds or the Central Karamaea country. Tracks being practically non-existent, pack-horses can be used to only a limited extent; the men for many miles would have to carry on their backs all the necessary tools, camp equipment, and food supply, and as the carrying capacity of the human being at any time is not great it follows that they would land at the scene of their actual prospecting operations not merely poorly supplied with the necessities for an extended stay, but also physically exhausted from the strenuous work entailed by their long journey. The ordinary procedure is for the men to go in together. They may then prospect together as long as their supplies hold out when they have perforce to return to civilisation. Failing this method one of the men, once the region it is desired to examine is reached, may carry on the investigation by himself while his mate devotes his energies to packing in the required food. On rare occasions parties of this kind make a start at their work by first building a series of rough camps along their route, and subsequently packing their requirements from camp to camp until they eventually reach their objective with sufficient supplies to last them for a reasonable campaign. As a rule, however, the most primitive method is adopted, with the result that much loss of time in travelling to and fro is incurred, and any prospecting done is of a most superficial and hurried character. As, in cases where subsidy is given, payment usually starts from the time the men begin their journey, there is also much profitless expenditure of Government money.

As previously stated, the Mines Department, in its desire to encourage the testing of areas holding out any possibilities, has financially assisted these parties to no mean extent, but the writer has long doubted whether further expenditure of the kind is justifiable. Apart altogether from the hasty and inconclusive nature of the work done, there

are other aspects of this particular method of prospecting which tend to make it unsatisfactory. One of these is the fact that the men going out are as a rule but poorly equipped with geological or mineralogical knowledge, and are thus not fitted to make the most of their prospecting opportunities. Many of the men are earnest enough, some of them even carrying handbooks on these subjects with them and studying them religiously, but knowledge gained solely from books in this way tends rather to confuse the amateur than help him. In reports from prospectors the writer has often noted the results of such study. One such prospector wrote to the effect that he had discovered a lode, "the matrix of which appeared to be one of the heavy earthy carbonates, witherite, celestine, barytes, or carbonate of lead with silver, but after all the examination I can give it appears more likely to be fluorspar with chlorite, bromide, or iodide of silver." Other bad features are that the men go out with no intention of searching for any but one mineral, and that it is quite impossible under existing conditions to exercise any supervision over the work, and there is thus no means of telling what amount of effort was made or in what direction it was made, or, in other words, whether the subsidy granted was expended wisely or not. A still further unsatisfactory point about such work is that no data of any permanent use is furnished as the result of it. With all its imperfections this small-party prospecting cannot, however, be unreservedly condemned; indeed, as previously mentioned, it will still have to be adopted to some extent in connection with any comprehensive scheme the future may develop of investigating the country's mining possibilities, but the precaution must at least be taken to ensure that it is carried out under conditions offering some better chance of successful results than those now prevailing.

As far as those regions are concerned in which difficulty of access or of maintaining supplies have in the past either wholly prevented or, at best, allowed of only imperfect investigation, there can be little doubt that this method should be abandoned altogether, and that any future work should be carried out by larger parties of specially selected men, properly equipped and organised, and under the direction of a leader possessing sound technical and scientific qualifications.

This idea of large-party prospecting in outlying regions is by no means a new one. In New South Wales attempts were evidently made prior to 1912 to promote the formation of such parties, and in Western Australia work along this line was started in 1918, and has been carried on to a greater or less degree up to the present time. Even in New Zealand as far back as 1908 we find Minister of Mines, Hon. Jas. McGowan, in his annual report to Parliament making the statement that: "Whilst the State has for years encouraged small parties of prospectors, it cannot be affirmed that the results have been commensurate with the expenditure. It would appear, therefore, that the time has now arrived for a forward move. Prospecting parties, under the control of the Mines Department, should be properly equipped, and endeavours made to discover new lodes of auriferous quartz, deep leads of alluvial gold, or economic minerals. . . . Small parties of prospectors have, as a rule, kept too close to the beaten tracks and the old workings. An endeavour should now be made to penetrate into outside districts, and so pave the way for mining developments in portions of the Dominion that are at present little known." As a matter of fact one party such as referred to was formed and sent out, but, owing to financial stringency in the Dominion's affairs, it was, unfortunately, only kept in the field for a very short time.

It needs no very close study, of course, to bring to anyone considering the matter the realisation that the organising, financing, and controlling of such parties present many difficulties, but none of these seem insuperable. Regarding the first item, organisation, it would seem essential that, whatever the qualifications of the rank and file, the leader should be in absolute control, and be possessed of special technical and scientific mining knowledge, as well as have some gift for handling other men.

When the first Western Australian parties were formed in 1918 the plan was tried of merely giving the men a little elementary training beforehand, and leaving them practically to their own resources in the field, no leader being appointed. This, as might have been expected, did not turn out a satisfactory method of procedure. Some of the parties hung around the mining centres, doing little prospecting, while others only tried old abandoned ground, and

none of them did much good. Dealing with the organisation of those parties C. M. Harris, who had much to do with the training and equipping of them, expressed the opinion in a paper read before the 1919 meeting of the Australasian Institute of Mining and Metallurgy that the whole system of prospecting then followed would need to be revised before any measure of success could be counted on. His suggestion was that, instead of a short course of training being given to all the men forming the parties, a few members should be picked out who had the brains and education to assimilate the necessary knowledge and were capable of leadership, and given an intensive course of study in simple Mining Geology extending over at least six months. Better still, he thought it would be, if young men who had been trained at a School of Mines and had a practical knowledge of mining, were given special instruction in the work and placed in charge of the parties.

Should any parties be formed in New Zealand it would appear essential, therefore, that there should be a leader, and that he should have the right kind of training. It would be a good thing, of course, if all the men taking part could receive some amount of training, but this is much less necessary than that they should be led by a competent man and wholly under his control.

In Western Australia the primary idea in forming the parties was to enable localities to be investigated which it was believed the independent prospector had not been able to properly examine owing to shortage of water in them or some other disadvantage. In New Zealand the trouble with our untried areas has not been lack of water, but difficulty of access or of maintaining supplies. This trouble still confronts the prospector of them, and, to get over it, before any actual prospecting is started by a party, well-stocked depots would need to be established as near as possible to the proposed scene of operations. Once work was begun the men would not then be under the necessity of making frequent trips to and fro for supplies, and could be kept almost continuously in the field, thus reducing loss of time and money from this cause to a minimum. The leader would set out the work, giving each man, or pair of men, a certain section of country to go over, directing them in the precise manner in which they should operate, and as closely as possible inspecting the work done; he would

make special examination of anything of a likely nature disclosed, and personally supervise the taking out of samples for assay or analysis; finally, he would fully map the whole country traversed, and thus provide a permanent record of the work, which in itself would be worth a good deal of the expenditure incurred in connection with the expedition.

The number of men employed would depend on the funds available, and their selection should be left chiefly to the leader. In cases where the work was being done wholly or partly with Government subsidy, the local Inspector of Mines could perhaps assist the leader in choosing the other members of the party. In any case the party should not be too small to prevent a reasonably large area of country being examined in a season of, say, six months, nor too large as to be unwieldy. With six men, exclusive of the leader, good progress should be made. This would permit of two pairs of men being kept always in the field, while one of the remaining pair could attend to the shifting of camps, packing of supplies, etc., and the other to cooking and general camp duties. By allowing each man to attend to his own share of camp work, the three pairs could be available for the actual prospecting, but this arrangement would necessitate a certain loss of time for all hands.

There seems no special reason for anticipating any serious difficulty in securing suitable leaders, but it is doubtful if the same can be said with any degree of confidence regarding the getting together of the right kind of men to make up the balance of the parties. The old type of prospector who preferred this work for its own sake is now rarely met with, and his modern descendants, having lost much of the mining instinct, are not readily tempted away from the good wages so easily securable at other callings. If a more liberal sustentation allowance than that now made under the Mining Regulations—namely, 39s per week per man, were available, men might be tempted to take up the work more freely. When an attempt was made, in the recent past, to form one of these parties on the West Coast, the writer was approached by a number of men who professed a desire to join it, but inquiry revealed the fact that they wanted £5 per week allowance, as well as an interest in any discovery that might be made. The present-day attitude of the man who still retains some weakness for the prospecting life seems to be that, in view of the increased

cost of living, and of the fact that he can earn good money at other employment, it is not reasonable to ask or expect him, especially if he be married, to undertake the rough, hard work of pioneering for less than a full wage.

It is not uncommon also in mining localities to hear the Government blamed for the falling off in prospecting effort, the said falling off being attributed to the smallness of the subsidy now payable.

It may be, from one point of view, that a man going out prospecting now should be worth more money than formerly, but the writer is not at all sure that the giving of a full wage for the work would in itself lead to any very useful result, and has no hesitation in expressing the opinion that, even if the payment of such wage is necessary to secure the right type of men, the Government should not provide a greater portion of it than at present. It seems essential there should be in the make-up of a good prospector a strong touch of enthusiasm, a capacity for some measure of self-sacrifice, and a dash of the gambling instinct, and the prospector whose chief concern is his wage is doubtfully the possessor of that peculiar spirit which gives him his best value, and, as far as Government subsidies go, they were never meant to provide a living wage, but merely to serve as a reasonable help to enable miners to carry out prospecting efforts they themselves had planned, and which they were convinced would result finally to their personal benefit, nor would it seem that more than this could be expected.

Governments have many duties to perform in the public interest generally, but the development wholly at their own expense of any particular industry can scarcely be deemed one of them. It is probable that to secure men for prospecting parties something better than 39s per week will have to be paid, the balance between this sum and any increased allowance given will almost surely have to come from some other source. In other words, if greater expenditure becomes necessary the mining public, which will ultimately benefit from any good results an active prospecting scheme will yield, should share with the Government the burden of carrying it out, and, later on in this paper, suggestions will be offered as to means by which this assistance may be arranged for. In the meantime it may be

said that, in any case, when a bona fide forward movement has been launched, it is probable that many enthusiasts will come along well satisfied to take on the field work with a reasonable sustentation allowance, on the off-chance of otherwise materially improving their positions by the making of a few valuable discoveries.

In whatever way the parties are organised, the members should be entitled to a certain interest in anything or everything of the nature of mineral finds that may be made, and the area under investigation should be reserved from mining occupation during the period of the examination, to prevent free-lance prospectors taking unfair advantage of the party's work.

The effective financing of this large-party method of prospecting presents a more serious problem. The New South Wales and the later Western Australian expeditions appear to have been wholly carried out at Government expense. The one effort of the kind made in New Zealand was also evidently a purely Government venture, and, according to the Hon. McGowan's Mines Statement of 1908, the intention of the Government of that day was to finance all parties that might be sent out and keep them under the control of the Mines Department. In spite of this latter fact, however, the changed conditions that time has brought about render it most unlikely that future prospecting of this nature in the Dominion will be undertaken on such lines.

It may be taken as practically certain that for any scheme that may be evolved Government help will be forthcoming, and there is no reason for thinking otherwise than that such help will be liberal. Our Governments have at all times been generously disposed towards the mining industry, which is perhaps as it should be, considering how important a thriving industry of the kind is to any country. It is to be hoped the kindly treatment of the past will be continued.

What the total expenditure of public funds has been on works carried out in the interests of mining is now somewhat difficult to estimate, but a glance through the files shows that in the West Coast Inspection district alone subsidies for prospecting of all descriptions amounting to £55,634 have been granted, with a further £20,000 by way

of loan. In the construction of mining water races over £304,000 has been spent, and on mining roads and tracks some £220,000. Other items of expenditure such as the provision and upkeep of Keystone and Diamond drills, subsidies to School of Mines, and geological surveys have added considerably to the gross outlay. Expenditure of this extent serves to indicate in a general way what the attitude of the Government towards any movement such as here proposed may be expected to be, but the exact nature of the assistance to be looked for cannot even be guessed at—it may be £ for £, or even £2 for £1. The question is as to where the balance of the necessary funds to effectively carry the scheme through is to come from.

There seem to be three ways at least offering whereby the money may be raised. Purely local Prospecting Associations may be formed to find just the quota necessary for the examination of areas in the immediate neighbourhood. Provincial Associations may be got together to deal with the prospecting of each province as a whole, or a National Association may be promoted to undertake the work in the interest of the whole Dominion. As far as the first mentioned method is concerned, the writer does not think its adoption is to be advised, or would lead to the desired result. The one effort made in New Zealand within recent years to finance a party in this way was a failure. Two years ago the residents of Hokitika, desiring to have a thorough examination made of at least one of several Westland areas believed to have mining possibilities, appealed to the Government for assistance in the matter, with the result that the Minister of Mines promised a very liberal contribution, subject to the condition that the local people should find the balance of the money required. Despite the fact that the latter was only the comparatively small sum of £400, it was found impossible to raise the amount, and the proposal fell through. This failure to find their quota does not reflect on the enthusiasm of the local residents. It so happened that at the time the town was very busy preparing for its Exhibition, which opened in December, 1923 and in connection with which many of the leading tradespeople had been called upon to enter on considerable monetary outlay; but even had this call on their enterprise been missing it is questionable if the prospecting proposal would have met with any greater measure of success.

A small district can scarcely hope at any time to carry a scheme of this character through successfully, the local or parochial character of the movement being against it, and the onus of finding the necessary money falling on too limited a number of possible contributors. Had there been a Provincial or a National Prospecting Association to come to the rescue at the time the probability is that the proposed party would have been formed, and much good might have resulted. Whatever attempt is made in the future by way of promoting a movement on behalf of the general public with the object of reviving and encouraging systematic prospecting, it would thus seem that it should be on lines which will offer a wider appeal than the localised effort possibly can.

The formation of Provincial Associations, which would afford an opportunity to the people of each of the provinces to help along the mining interests of their own division of the country, might prove to be a solution of the problem, but, in view of the many and serious differences that can, and do, exist between the residents of different towns even in the same province, the building up of a strong National Association would appear to be the most commendable way of dealing with the matter. Such an association would be free of parochialism, would have an appeal to everyone within the whole length and breadth of the Dominion with any interest in mining, and, which is infinitely more important, would, from the width of its constitution and scope, draw to its support a more highly trained and experienced type of mining man than the other kinds of associations would have a chance of doing. The West Australian writer C. M. Harris, in his paper previously referred to, made mention of a suggestion by a Canadian, Mortimer Lamb, of forming, for the same purpose as is discussed here, a national prospecting company under a board of management, composed of mining engineers of repute in whom the subscribing public would have confidence. Tens of thousands of pounds, it was pointed out, are lost annually by the public all over the world in prospecting syndicates and in small gold-mining companies because they are badly handled, whereas with such a company the shareholders would be sure of having the best advice possible, the management would be above reproach, and high-class leaders would be secured. The suggestion here made was for the forma-

tion of a company to carry on the prospecting work of Canada apart from Government control or assistance, hence the plan does not altogether fit in with local requirements. In New Zealand any national movement instituted for the purpose would have to be one whose object would be to work in hand with the Government and supplement the latter's efforts, nevertheless the good features claimed for the Canadian plan would be just as applicable to one as to the other.

There is no reason why a national prospecting association formed in this country with the object mentioned should not have on its board of control the best mining talent the Dominion possesses, and with this talent to assist the Government, and at the same time safeguard the interests of subscribers, the movement should have the confidence of the mining public, and little difficulty should be experienced in raising all the funds required. The total amount needed should not be large, and, provided its expenditure is trusted to competent hands, it is hard to believe that, in a country like New Zealand, that owes its present state of prosperity to so great an extent to mining, there would not be a sufficient number of public-spirited citizens ready and willing to see such a scheme to completion. The various mining companies operating in the Dominion should find it to their advantage to support such a venture, and the local authorities, which in mining districts would immediately benefit from any improvement in the industry, might reasonably be looked to for assistance in the matter.

As to the control of such parties that would have, of course, to depend on the arrangements made for their financing. The West Australian parties, which were financed by the State, were under the control of a Prospecting Board, consisting of the Government Geologist, the State Mining Engineer, two representatives of the Returned Soldiers' and Prospectors' Associations, two mining engineers representing English and Australian capital, and the Assistant Secretary of Mines. A board of some such nature could control them there, but if a National Prospecting Association were formed, as suggested, a more limited personnel would suffice. The board could, for instance, merely consist of the Director of Geological Survey the Inspecting Engineer of Mines, three representatives of the association (say, two mining

engineers and a member of the professorial staff of the Otago School of Mines), one representative of local bodies (should such contribute), and the Under-secretary of Mines.

Apart from the formation of such an association as described, the next most important move, if prospecting effort in the Dominion is to be effectively revived, seems to be that of improving the education of our prospecting community with regard to such matters as elementary geology and mineralogy. Reference has already been made to the very indifferent acquaintance our prospectors now have with such subjects. Other countries have experienced the same conditions and taken steps to remedy them.

When the earlier parties were being got together in West Australia in 1918 a scheme was devised whereby, before the men were sent into the field, they were given a short series of lessons in the testing of economic minerals and in preparing samples of ore for assay, the idea being to teach them to recognise both valuable and worthless minerals. Each party was supplied with a small collection of typical minerals for comparison in the field with anything that might be found.

In the Canadian Province of Ontario a somewhat similar plan was adopted. Realising the necessity, if its mining resources were to be fully developed, of making its prospecting community thoroughly familiar with the appearance and occurrence of those minerals most likely to be found within its territory, this Province adopted the course of sending a competent instructor, armed with 30 to 40 typical mineral samples, from camp to camp to give lessons to the men. Prior to his visit to any camp, communication was established with a local resident of some standing, whose duty it was to secure a suitable room for the giving of lectures and display of specimens, and to get into touch with all prospectors willing to avail themselves of the instruction offered. There was no difficulty in securing enthusiastic advance agents of this kind, and at each camp the attendance of prospectors is said to have been very encouraging. Lecturettes were given the men on the occurrence of the various minerals and their properties, and, when they had familiarised themselves with the specimens exhibited, small pieces were given to each to carry with them.

Any knowledge imparted in this way must necessarily be superficial, but it can scarcely fail to be of considerable value to the men themselves, and to the country in general.

In New Zealand the average man who applies for prospecting assistance is perhaps even less familiar with commercially important minerals than the ordinary prospector elsewhere, for the simple reason that he has not had the same chance of studying their appearance and occurrence, and an effort of some kind seems necessary by way of improving his knowledge in this regard. Our mining centres are, however, so scattered and at present so depressed, and, what is worse, the genuine prospecting element has evidently shrunk to such insignificant proportions, that it is extremely difficult to see how this can be done.

By the establishment of Schools of Mines and the collection of suitable mineral specimens at a number of local centres, the Dominion has already made an attempt to cope with the defect, but the results do not appear to have been as satisfactory as might reasonably have been hoped for. This was probably due to little effort being made by the schools along the right lines; instead of reaching out for the prospector and giving him the knowledge he stood in need of, they devoted themselves for the main part to coaching candidates to face Boards of Examiners. It will be understood, of course, that only the district Mining Schools are here referred to.

The writer understands that many years ago a number of prospectors on the Thames goldfield banded themselves together and formed a number of miniature Schools of Mines in the outlying mining centres, which were visited periodically by instructors from the Thames School of Mines, who taught the men elementary mineralogy and geology. This seems to represent practically the only instance made by a Government Mining School to educate the prospector. In any case so few of the schools remain that any use they might now be put to in this direction is very limited. Probably the only way left in which they might do some good is by inviting would-be prospectors in certain mining centres to form classes which the instructors could attend for the purpose of giving brief courses of instruction specially prepared to meet the requirements of the men. The writer has been assured that at Hokitika such a class could be organised, and if it were made known generally that such

special courses of instruction would be given, providing the necessary encouragement was forthcoming, it is very likely that similar classes could be got together in many other centres.

Education of this kind is perhaps not so necessary for men joining up with large parties under trained leaders, but for the small-party prospector it seems essential, and, failing some effort to effect the purpose by arranging for this class instruction, the only other means available appears to be to provide bona fide prospectors with small portable collections of typical minerals. Collections of this kind, however small, would cost money, and they could not be given out indiscriminately, but something useful might be effected along this line without any very serious expense being incurred.

Other means by which prospecting effort may be promoted and induced to yield more satisfactory results are by encouraging men in the field to send in samples more freely for determination, and by enabling them to get assays and analyses made at low cost, if not entirely free of charge. Most of the men who go out are but poorly equipped financially, and as the postal charges on parcels of stone soon run into a good sum, the tendency is to avoid sending them.

If a concession in postal rates could be secured for bona fide prospectors' samples, a small extra allowance made to cover this expense, or an arrangement come to for the charges to be paid by the prospecting association, it might lead to many more samples being forwarded, with consequent good results. With regard to assays and analyses it is needless to say that any charge for these, other than a merely nominal one, is a definite bar to the prospector sending samples in. The writer understands that at the Dominion Laboratory the charges for this work range from 10s 6d for a simple assay of one mineral (gold and silver being counted as one) to £3 3s for an analyses, but these are probably only made in cases when the locality from which the sample came is not furnished, or where there is reason for thinking it is not from a genuine prospector. Indiscriminate free assaying, etc., by Government departments is not altogether a commendable practice, if only

because it is one lending itself to ready abuse, but prospectors cannot pay the charges above mentioned, and must receive very liberal treatment if they are to be encouraged to their best efforts.

A National Prospecting Association might help materially by arranging for all prospectors' samples to be sent to it for examination at some central laboratory either paying itself for the work or ensuring that the man in the field is only charged the lowest possible rate. It could also assist by seeing that all testing was carried out without unnecessary delay, by making sure that a truthful description was given as to exact locality from which the samples came, and by keeping careful records of all results.

So much for actual prospecting. If metalliferous mining is to be revived, investigation of our mineral areas along some such lines as have been indicated would appear to be the first and the essential move to be made if any ultimate good is to be looked for. It may be, of course, that no amount of effort in this direction will improve the position of the industry, but this much is certain, that if we do not seek we will not find; unless the prospector, pick in hand, leads the way, effort in other form can avail little. It can, therefore, scarcely be too strongly urged upon those who have the welfare of this branch of mining at heart that they should use their best endeavour to ensure that something in the way of a scientific and determined scheme of prospecting is set afoot. The move certainly seems worth the making, even if failure should be its final reward.

There are other lines that may assist, in conjunction with comprehensive prospecting, to restore our metal mining to a healthier condition, such as, amongst others, the keeping in the future of much fuller geological plans of our mines than has been the custom in the past, the setting aside of an official to give his undivided attention to our mineral industry, the establishment of some authority to pronounce upon proposed new mining flotations before the prospectuses are placed before the public, and the extension of geological survey.

As to the first of these it may be said that in past years only a few of the largest mining companies have made any serious effort to preserve exact and reliable data concerning

the geological features revealed in their workings. For some years all mines of any importance have kept plans and sections showing the actual development, but, with few exceptions, these contain little information as to the dip of strata, strike and dip of faults, position of intrusions, character of wall-rocks, etc., and the result is that, in the case of many mines that are now closed down and water-logged, there is so little to go on that the most expert mining geologist would be at a loss in trying to arrive at an idea as to what future possibilities the properties might possess. If laxity in this regard has prevailed in the past there is no reason why it should be allowed to continue.

Regarding the other suggestions just made, whilst they all have something to recommend them, it may be pointed out that, from their very nature, they cannot well be discussed here without intrusion being made into what may be described as the departmental or even political sphere, consequently the writer, as a Government official, only feels at liberty to deal with them in very brief and very general terms.

There can be little doubt that if it were at all possible to provide in the Dominion for an officer of special training and ability to give his whole attention to the mineral industry there are innumerable ways in which his talents could be employed to the advantage of the prospector, the mine manager, the metallurgist, and even the company promoter, but any such appointment would necessarily have in it the experimental element, and would be so decidedly an innovation on past practice that one can readily understand its wisdom being questioned. It may be mentioned, however, that when Ontario some few years ago made Willet G. Miller its Provincial Geologist it made such an experiment. That appointment was made for the express purpose of enabling Miller to give his undivided attention and interest to the province's mineral industry, and the result seems to have been more than satisfactory. Single-handed, Miller may be said to have developed the corundum industry in Canada, and he was admittedly the father of Cobalt, in which important mining field it has been claimed no discovery was made which was not directly or indirectly due to his guidance. Writing of him in the "Canadian Mining Magazine" of February 27, 1925, just after his

death, Dr R. W. Brock, of the University of British Columbia, was able to say: "He was given the opportunity, as it might almost be said, of creating mining in Northern Ontario, for the development of mining there was due to his work and his advice as nearly as it is possible for a movement of this nature to depend on one man." It is probably true that at the time Ontario had more virgin country to exploit than New Zealand possesses, and had greater mineral resources; it may also have been that it had greater national wealth, and was thus better able to afford experiments of this kind. But our Dominion has some possibilities, and, given the right kind of man, there is just the chance that the work Miller did there might be emulated to at least some useful degree here.

Could an authority be established to pronounce upon proposed new mining flotations before the public was invited to subscribe to them, there can hardly be any gain-saying that such a move would be in the best interest of mining generally. No one at all familiar with the nature of the general run of flotations that have been of late years worked off in the Dominion can fail to see that, instead of forwarding the metalliferous mining industry, they have done it great harm. As a rule the names of mining engineers of acknowledged high standing have been conspicuous by their absence from the prospectuses, and no really expert advice and guidance has therefore been available to the speculator, with the almost inevitable consequence that many willing supporters of mining have invested in ventures that had little or no chance of success, and eventually found themselves with parcels of valueless scrip on their hands, with sadly depleted pockets, and the determination to stand clear altogether of mining investment in the future. Apart from that, the extent to which the promoter has at times helped himself to benefits under such flotations has been a thing to marvel at.

New Zealand is not the only country in which the company promoter is given a free hand; much the same latitude is allowed him in many parts of the English-speaking world, and there seem many difficulties in the way of remedying the position. Practically all the great institutions of mining engineers have long appreciated the ill-effect upon the industry these badly-advised, badly-balanced flotations have had, and have considered ways

and means of overcoming the evil, but up to the present the ingrained reluctance of the Britisher to interfere with rights and privileges sanctioned by long custom has apparently been against the introduction of any very effectual remedial measures. Something needs to be done, however, by way of safeguarding the general public with regard to these flotations, and in the best interests of mining as a whole it cannot be done too soon.

As to the extension of geological survey, it may be pointed out that up to the present only about 15,500 square miles, or approximately one-seventh of the area of New Zealand proper, has been surveyed in detail. An account of the present status of a real geological mapping in detail in the Dominion, taken from a recent publication prepared by P. G. Morgan, Director of Geological Survey, may be of interest. This shows the position to be as follows:—

	sq. miles.
Areas in which surveys are completed, and work published on the 1-63,360 scale	8,803
Area in which survey is completed, and work published on the 1-126,720 scale	325
Area in which surveys are completed, but work is not yet published	5,327
Area in which survey is in progress	677
Area in which work is suspended	293
	15,425

Mr Morgan points out that much reconnaissance survey has been carried out, and that in view of this and of the fact that most of the country remaining to be surveyed is less difficult than that already mapped, more than one-seventh of the work required to make a complete geological map answering to the requirements of the present day has in reality been done, but he says that in order that this claim may remain true the present survey must be completed during the present generation, otherwise the progress of geological science will render the work already accomplished partly obsolete before the detailed survey now in hand has reached every part of the country.

It may be taken as certain that the work has been pushed on as rapidly as the country's finances permitted, and no complaint is here made as to delay in its performance. Reference is merely made to the position of the survey by reason of the fact that it so happens some of those particular parts of the Dominion to which the prospector in the past has not been able to give close attention are still included in the unsurveyed portion, and the hope may thus be expressed that, in the general interests of mining, ways and means of extending the work to them will offer themselves.

The intention had been entertained of giving in this paper some description of actual modern prospecting methods, also of the minerals likely to be found in commercially important quantities in New Zealand, the localities in which they might be sought the particular areas in which field examination has been negligible or imperfect, and so on, but it was felt that the inclusion of such matter would make the paper unduly long, and that, moreover, inasmuch as such information is readily obtainable elsewhere, no very useful purpose would be served.

The writer may thus be permitted to conclude with the statement that in preparing the paper he has merely aimed at offering some suggestions or ideas of a constructive nature, which appealed to him as likely, if put into effect, to help metal mining in this country out of the rather depressing position into which it has fallen, in the hope that, if they be considered too impractical, a discussion of them by this conference, probably the most important gathering of mining men the Dominion has seen or is likely to see for many days to come will lead to others being disclosed or developed, whose employment will better serve to bring about the result so greatly to be desired.

MINING EDUCATION ON THE WEST COAST, SOUTH ISLAND, NEW ZEALAND.

By J. F. McPADDEN, Director Westport School of Mines.

In 1884 the late Professor Black, of Otago University, visited the various mining fields of New Zealand and delivered lectures on chemistry, assaying, and the testing of minerals. The outcome of his tour was the establishment of several Schools of Mines throughout New Zealand. In 1886 two main schools were established on the West Coast of the South Island, one in the gold-mining centre of Reefton and the other at the coal centre of Westport.

The Reefton school had branches at Caplestone and Globe Hill and the Westport School branches at Denniston, Gravity, and Millerton. The Westport School had a varied career, and for lack of interest and financial assistance soon closed down. In 1897 it was reorganised, and Mr James, Assayer to the Anglo-German Exploration Company, was appointed director. He held the position for two years, and the school again closed. After a year Mr D. Strachan, M.A., took charge, and successfully carried on the work of the school for three years. He was followed in succession by Mr Sidney Fry, G. L. Hereus, H. Lovell, and J. F. McPadden. Although the school had a hard struggle, it eventually reached the level of the other Schools of Mines in New Zealand. The activities of the Westport School are mainly confined to coal-mining, and the large number of colliery managers, under-viewers, and deputies who are indebted for their instruction to this school reflects credit on all concerned in its management. At the present time the Westport School has branches at Denniston, Gravity, Millerton, and Seddonville. In March, 1923, a fine building was completed at Gravity for the use of mining students.

In 1886 a School of Mines was erected at Reefton by public subscription. As gold mining was more active than coal-mining, the Reefton School had a very successful career from its inception. Its record in the number of candidates who have gained their certificates of competency compares favourably with that of any school in New Zealand. The first director was Mr T. Fenton, followed in turn by R. M. Aitken, J. H. Lee, T. O. Bishop, J. Henderson, J. F. McPadden, and J. H. Lee. Much experimental and spade work in connection with the cyanide process for the leaching of gold-bearing sands were carried out at the Reefton School of Mines.

In 1914 the Reefton School extended its activities to the coal-mining centres of the Greymouth district. At the present time there are branch schools at Wanuta, Dobson, Runanga, and Blackball. The sole director-instructor is thus called upon to give instruction to candidates for colliery manager, metal manager, battery superintendent, and bullion assayer's certificates. It will be seen that he has a difficult task, and requires to be an encyclopædia on mining subjects. It is impossible to give considered lectures at either the Westport or Reefton School; each school is in reality a coaching institution. The chief business of these schools is to give instruction in technical subjects to practical miners. The training of mining engineers is left to the Otago University School of Mines, and the training of mine managers to the schools at the different mining centres. It is to the credit of schools such as Westport and Reefton that many men who had scant primary education succeeded in obtaining their certificates of competency, and to-day hold important positions throughout the mining world. The majority of students had to be taught decimals, and only by perseverance and coaching was success obtained. Taking into consideration the variety of subjects taught and the amount of travelling necessary in connection with branch schools, both these schools have proved their utility and reflect credit on all responsible for their upkeep and management.

Each school is managed by a Council elected from subscribing members, and it gives the writer much pleasure in placing on record his appreciation of financial aid and lively interest taken in the schools by members of the Councils. The Reefton School is much indebted to Messrs

Brett, T H Lee, and W Auld, and the Westport School to Messrs James Bradley, J C Brown, and T Fairhall, and both schools to the local Inspectors of Mines, Messrs Duggan, Downey, and Strongman. The Mines Department grants a subsidy towards the director's salary, and also subsidises £1 for £1 all fees and donations received. The Westport School receives generous donations from the Westport Coal Company and the Stockton Coal Company, also from the local Borough Council and County Council. The Reefton School is handicapped in that it received no donation from either mining companies or local bodies.

Although the Mines Department have in the past generously assisted these schools, the question arises whether the time has not arrived for the department to bear the whole expenditure. The present system was all right when Mining Schools were inaugurated for the need of a school could be judged by the support received locally. Mining has its ups and downs, and during the latter local bodies such as Borough Councils and County Councils must tighten their finances, likewise mining companies. It is unsatisfactory for an educational institution to have its finances fluctuating. A lesson could be learned from Great Britain, which is experiencing a bad slump, and yet increased grants are being made for mining education. Within limits the same should apply to New Zealand.

The writer would like to record here that directors of Schools of Mines, the Thames School excepted, hold an unique position, in that there is no provision made for superannuation. Men holding the qualifications to take charge of a School of Mines should certainly have their future assured. Even should it be necessary to close a school owing to a mining centre becoming decadent, it should be possible to transfer men of such ability to some other position or department. By comparison with Technical Schools, the directors of Schools of Mines are not receiving due consideration. The standard of instruction is high, and in addition Schools of Mines can claim to be mainly responsible for the low accident rate throughout the mining fields of New Zealand. This is brought about by reiteration of dangers, discussion on the same, and the fact that a director is in personal touch with the miner. In dealing with accidents, an anomaly exists in that workmen's inspectors do not necessarily possess any

certificates of competency. It appears to the writer that they should be required at least to pass a gas test. A miner with inferior eyesight might easily be appointed to such a position. It is a remarkable fact that the miners who continually advocate the nationalisation of mines and the means of production, distribution, and exchange generally do not take advantage of the facilities offered to extend their knowledge. The explanation probably lies in the fact that such procedure would be considered by their comrades as pandering to the "boss."

The scholarship provided by the Mines Department has not appealed to West Coast students, and the reason is not far to seek. The average student is a practical miner, and he prefers to obtain his mine manager's certificate and endeavour to obtain a position in charge of a mine. Several students, now holders of manager's certificates, have qualified in five out of the six subjects necessary for the scholarship. A student who has served his time underground and is capable of winning the scholarship is also capable of obtaining his manager's certificate, and under present conditions he prefers the latter. A scholarship winner should not be compelled to take a course of lectures at the Otago University School of Mines in subjects in which by virtue of the scholarship he has already proved himself competent. The writer would suggest that he be given credit for the subjects in which he has already proved competent, and the time so gained be applied to Advanced or Research work. This step would certainly appeal to a practical miner.

In connection with the mining examinations for certificates of competency, it is to be regretted that wherever possible additional cost has accrued to candidates. A simple gas test costs seven shillings and sixpence, examination fee for deputies fifteen shillings, for first-class manager's certificates two guineas. Further, candidates for mine managers' certificates, if successful in the written examination, are required to travel to Wellington at their own expense for the oral examination. At one time the Mines Department paid the actual expenses of successful candidates, but recently this has been discontinued. Take the example of a candidate from Millerton for first-class certificate. His entrance fee is two guineas; he has to proceed to Reefton for his written examination at a

cost of five pounds; later he proceeds to Wellington at a cost of about twelve pounds; total cost, nineteen pounds. This is not encouraging mining education, and the writer, in order to lessen the expense, would suggest that on the West Coast the written examinations be held at Greymouth and at Granity. If candidates are called to Wellington the actual expenses should be paid by the Mines Department. Failing this, the oral examination should be carried out in the different mining centres by the Chief Inspector of Mines, the District Inspector of Mines, and one other member of the Board of Examiners. With very little cost the latter could be easily carried out. Every encouragement should be given to candidates, as the more qualified men are, the less accidents there will be and the general efficiency of mining higher. Again, the writer would state that a lead should be taken from Great Britain, where every encouragement and facility is given to candidates.

A conference, say, every three years, between the directors of School of Mines and the Board of Examiners is desirable. Such conferences would be of much benefit to mining education. Again, the directors from the different schools should occasionally meet, as is the practice with all educational bodies, and by exchange of views generally improve the standard of mining education.

THE MINING INDUSTRY OF NEW ZEALAND— STATE AID TO AND REVENUE THEREFROM.

The object of this paper is to have recorded in a brief form some figures relating to the mining industry of New Zealand and to the direct benefits therefrom to local bodies and others, so that any persons sufficiently interested may realise the value of that industry to the Dominion.

The amounts expended by the Government between the dates hereinafter mentioned are as follows:—

	£	s.	d.
Expenditure by Mines Department upon the purchase or erection of public batteries at Coromandel (1900), Mahakirau (1894), and Kuaotunu (1906) ..	2,409	13	8
Diamond and other drills (1/4/1906-31/3/1925) ...	20,068	13	0
Roads and bridges (1/1/1873-31/3/1925)	990,814	5	8
School of Mines (1/1/1885-31/3/1925)	126,798	18	9
Subsidies—			
Assistance to prospecting, etc. (1/1/1871-31/3/1925)	159,904	14	2
Loans under Mining Act (1/1/1913-31/3/1925) .	69,723	4	6
Assistance to oil-boring companies:			
Loans (1/1/1913-31/3/1925) £21,824	0	0	
Bonuses 8,750	0	0	
	30,574	0	0
Bonus for production of quicksilver (1917-1921) ...	581	5	0
Bonus for production of shale oil (1903-1904) ...	5,000	0	0
Water races—construction, management, and operation (1/1/1877-31/3/1925)	432,754	1	2
Other purposes connected with the fostering of mining, including grants to libraries, aids towards treatment of ores, artesian well-boring, resumption of land for mining, repairing flood damages, wharves, drainage, and tailings channels, etc., etc., from 1/8/1871 to 31/3/1925 (approximately)	40,000	0	0
	1,878,628	15	11
Geological Survey (31/3/1906-31/3/1925)—from 1/1/1873 to 31/3/1925)*	111,272	16	3
	£1,989,901	12	2

In all fifteen sums were advanced by way of loan to mining companies since 1913, and three sums were similarly advanced to oil-boring companies.

No less than 915 mining companies and prospecting parties have been granted prospecting subsidies by the Mines Department since the year 1883. Prior to that similar assistance was granted, but separate records showing the expenditure were not kept.

*Prior to 1905 there was no separate vote for the Geological Survey, and consequently the expenditure for such survey up to that time cannot now be given.

Bonuses in aid of the production of minerals have been offered by the Government from time to time in respect of the following minerals:—

Mineral	Amount Offered	Conditions	Time Limit	Gazette	Date
Antimony	500	for first 250 tons produced	30, 6, 1884	5/7/1883	
Briquettes	2,000	for successful manufacture of briquettes or of coke and other by-products from sub-bituminous or brown coal slack for commercial purposes	Approved 9/1/1925.—Conditions not yet determined.		
Copper	1,000	on 1000 tons produced before 30/6/1909	—	25/7/07	
	500	on 1000 tons between 1, 7, 1909 and 30, 6, 1910	—	—	
	500	on 1000 tons between 1, 7, 1910 and 30, 6, 1911	21, 12, 1903	14, 11, 1901	
Invention	2,000	of appliance which will successfully save gold from blacksand	30, 6, 1886	2, 7, 1885	
Kerosene	1,250	on first 50,000 gallons at 6d per gallon			
Manganese and manganese-bronze	500	on first £2500 worth	30, 6, 1884	5, 7, 1883	
Marble	300	on first £1500 exported	30, 6, 1884	5, 7, 1883	
Mineral manure	200	for production of 200 tons	1, 8, 1897	6, 8, 1896	
Mineral manure	500	if found on Crown Lands) deposits discovered			
Mineral manure	250	if found on freehold lands) to be worked	1, 7, 1900	14, 12, 1899	
Mineral oil—					
(1)	5,000	1s per gallon on first 100,000 gallons	31, 12, 1884	17, 8, 1892	
(2)	5,000	1s per gallon on first 100,000 gallons	30, 6, 1900	3, 11, 1898	
(3)	6,250	3d per gallon on first 500,000 gallons	31, 3, 1913	14, 10, 1909	
(4)	10,000	on first 250,000 gallons produced	—	—	
(a)	2,500	on first 500,000 gallons produced	—	—	
(b)	2,500	on first 1,000,000 gallons produced	—	—	
(c)	2,500	on first 500,000 gallons of refined mineral oil produced	31, 3, 1915	22, 12, 1910	
(d)	2,500	NOTE.—Clause (d) in Gazette of 22/12/1910 revoked and following substituted therefor:—	—	—	
(i)	1,250	on first production of 250,000 gallons of refined oil	—	—	
(ii)	625	on first production of 375,000 gallons of refined oil	—	—	
(iii)	625	on first production of 500,000 gallons of refined oil	—	—	

NOTE.—Time limit extended to 31/3/1917 (Gazette No. 139, 14/12/1916).

Mineral	Amount Offered	Conditions	Time Limit	Gazette Date
(5)	12,500	3d per gallon on first 1,000,000 gallons of oil produced; not more than £2000 per year if found on Crown Lands) deposits discovered if found on freehold lands) to be worked ...	Cabinet 22/4/1924.—Not gazetted.	Not
Mineral phosphate	500	if found on freehold lands) to be worked ...	31/3/1907	12/7/1906
Mineral phosphate	250	if found on Crown Lands) deposits discovered if found on freehold lands) to be worked ...	31/12/1908	24/4/1908
Iron and steel—				
(1) Pig iron ...	1,000	for 300 tons	31/12/1883	6/7/1881
(2) Pig iron ...	1,000	for 300 tons	31/12/1886	11/12/1884
(3) Pig iron ...	500	for first 500 tons at £1	31/3/1893	7/7/1892
(4) Wrought iron ...	1,000	for first 200 tons of "Iron Blooms"	31/12/1884	5/7/1883
(5) Wrought iron ...	1,000	for first 200 tons of "Iron Blooms"	31/12/1886	11/12/1884
(6) Under Iron and Steel Industries Act, 1914 ...	150,000	12s per ton on pig-iron, puddled bar iron, and steel produced from pig-iron, and 24s per ton on steel produced from molten metal direct from the furnace. Not more than £75,000 to be paid in respect of pig-iron, or more than £30,000 annually	31/3/1924	By Act.
		NOTES.—(1) Bonus payable 3 years after date of production, thereafter rates decreased yearly for pig-iron and puddled bar iron by 2s per ton, and steel by 4s per ton. (2) Amendment Act, 1920; time limit extended to 31/3/1931. (3) Amendment Act, 1925; bounty increased to 30s per ton; time limit further extended to 31/3/1934.		
Quicksilver	1,666 13 4	100,000lbs at 4d	31/3/1899	19/9/1895
	1,666 13 4	100,000lbs at 4d	31/3/1901	3/3/1898
	1,666 13 4	100,000lbs at 4d	31/3/1904	10/1/1901
	1,666 13 4	100,000lbs at 4d	31/3/1911	25/7/1907
	1,666 13 4	100,000lbs at 4d	31/3/1915	25/4/1912
	1,666 13 4	100,000lbs at 4d	31/3/1921	9/8/1917
	1,666 13-4	100,000lbs at 4d	31/3/1923	16/9/1920
Salt	500	500 tons at £1	31/3/1893	7/7/1892

The following table shows the number of holes drilled, etc., by means of the Mines Department's drills between the years 1910 and 1924:—

Year.	No. of holes drilled.	Aggregate depths drilled for.			
		Alluvial gold. ft.	Auriferous quartz. ft.	Coal. ft.	Miscellaneous. ft.
1910	... 138	4,945	1,560	895	1,288
1911	... 92	3,793	523	1,312	—
1912	... 159	6,670	—	1,158	—
1913	... 119	2,949	—	2,743	400
1914	... 14	889	373	2,502	—
1915	... 52	2,006	—	5,001	754
1916	... 100	4,321	—	191	424
1917	... 102	2,984	—	625	576
1918	... 246	6,296	—	4,482	1,588
1919	... 71	3,877	628	5,029	—
1920	... 79	1,266	—	4,365	1,181
1921	... 31	757	—	5,029	370
1922	... 16	265	—	2,855	553
1923	... 45	2,775	—	3,253	421
1924	... 52	2,565	1,078	2,027	—
Totals	1,316	46,358	4,162	41,467	7,555

1316 holes have been bored for an aggregate depth of 99,542 feet.

Since the year 1852 the following table shows the quantity and value of gold and other minerals exported up to December 31, 1924:—

Name of metal or mineral.		Total from January 1, 1853, to December 31, 1924.	
		Quantity. Oz.	Value. £
Precious metals—			
Gold*	... ..	23,176,091	91,414,828
Silver	... ..	24,632,908	2,904,651
Total gold and silver		47,808,999	£94,319,479
Mineral produce, including kauri gum—			
Copper ore	... ..	1,504	19,390
Chrome ore	... ..	5,869	38,002
Antimony ore	... ..	3,781	55,045
Manganese ore	... ..	19,380	61,994
Hæmatite ore	... ..	77	469
Tungsten ore	... ..	2,340	301,870
Quicksilver	... ..	16	8,336
Sulphur (crude)	... ..	4,927	13,241
Mixed mineralst	... ..	72,306	306,807
Coal (New Zealand) exported	... ..	5,469,660	5,685,099
Coke exported	... ..	17,304	26,852
Coal, output of mines in Dominion (less exports)	... ..	54,134,688	34,553,610
Oil shale	... ..	14,444	7,236
Kauri gum	... ..	389,052	21,108,085
Total quantity and value of minerals		60,135,349	£62,186,036
Value of gold and silver, as above		—	94,319,479
Total value of minerals, including gold and silver		—	£156,505,515

*In respect of gold, ounces of the fineness of 20 carats and upwards, 1629 tons; also marble of weight unspecified by the Customs Department.

†Including pumicestone and pumice-sand.

As will be observed, the total value of minerals (including gold and silver) exported during the period referred to amounted to £156,505,515.

Since January 1, 1857, to March 31, 1925, the revenue paid by the Government to local bodies in respect of gold-fields revenue and gold duty was as follows:—

Goldsfields revenue	...	...	£3,090,671	3	4
Gold duty	...	...	615,562	17	5

£3,706,234 0 9

In several parts of the Dominion, as the result of expenditure by mining companies and others, permanent benefits have accrued, after cessation of the mining industry, to the inhabitants living adjacent to such works. By way of illustration, it may be mentioned that water races constructed for mining purposes are now used for the purposes of irrigation and generating electrical power for other than mining purposes. Large sums of money have been expended from time to time upon the construction of roads and bridges in many parts of New Zealand which, but for mining, would not now be available for public use.

During the years 1889-1890 an Exhibition was held in Dunedin which was known as the New Zealand and South Seas Exhibition, and a Mining Conference was held in the Town Hall, Dunedin, which opened on March 5, 1890. In order that a comparison may be made as to the relative positions of the mining industry for the years ended December 31, 1889, and December 31, 1924, the total value of gold and minerals (including kauri gum) exported during each of those years is given hereunder:—

Year 1889	...	...	...	£1,493,167
Year 1924	...	...	...	£3,237,331

AID AVAILABLE FOR PROSPECTING, ETC.

In no other country does the State offer such liberal and varied assistance to miners and prospectors as in New Zealand. During and since the war State aid to mining in this Dominion has been given in several forms—viz:

- (1) Geological survey and bulletins.
- (2) Financial aid to prospecting.
- (3) Government prospecting drills.
- (4) Loans for mining operations.
- (5) Schools of mines.
- (6) Subsidised roads to mining fields.
- (7) Government water-races.

GEOLOGICAL SURVEYS AND REPORTS.

Since the first discovery of coal and the precious metals in New Zealand the Government has employed skilled geologists, who have reported, after examination, on all the known mineral deposits.

Since the year 1905 the Geological Survey has made numerous detailed field surveys on a systematic plan, and 20,049 square miles have been geologically surveyed, but the reports based upon the whole of such surveys have not been published up to the present time.

STATUTORY PROVISIONS RELATING TO PROSPECTING, ETC.

Under the existing law assistance may be granted for prospecting as under:—

1. Subsidies for prospecting (vide Regulation 127 under the Mining Act):

- (a) For prospecting new ground by parties of not less than two men, a subsidy not exceeding £1 19s per week per man.
- (b) For sinking in dry ground by parties of not less than two men: From surface to 15 feet, 1s 11d per foot; from 15 feet to 30 feet, 3s 3d per foot; from 30 feet to 60 feet, 3s 11d per foot; over 60 feet, 5s 2d per foot.
- (c) For sinking in wet ground where slabbing is necessary, double the foregoing rates. For sinking in solid rock by blasting, 9s 9d per foot; but if the cost exceeds £1 19s per foot, then 13s per foot may be paid.
- (d) For tunnelling or driving through drift or blue reef: Up to 400 feet, 1s 11d per foot; 400 feet to 700 feet, 3s 3d per foot; 700 feet to 1000 feet, 3s 11d per foot; over 1000 feet, 5s 2d per foot.
- (e) For tunnelling or driving through hard rock by blasting, a subsidy of 6s 6d per foot is offered; but if the cost exceeds £1 per foot then 8s 8d per foot may be paid. When timbering by sets is necessary, then a subsidy not exceeding 2s 7d per foot of driving or one-half the cost of the timber may be paid.

2 Subsidies for prospecting deep levels for gold quartz lodes down to a depth of not less than 1000 feet, and for alluvial drift not less than 250 feet (vide Regulation 125

under the Mining Act): Such subsidies up to half the estimated cost of the work, but not to exceed £10,000.

The Minister of Finance may from time to time on the recommendation of the Minister of Mines pay to any person engaged in prospecting or pioneer mining a subsidy not exceeding 5s for every £1 expended by such person in prospecting or pioneer mining during the preceding twelve months. Not more than £500 may be paid to any person, nor more than £10,000 in the whole in any one year.

Subject to the provisions of the Mining Acts, loans on a £ for £ basis may be granted for carrying on mining and purchasing and installing plant up to £50,000 in each financial year.

The identification and assaying, free of charge, of samples from bona fide prospectors at the Dominion Laboratory, Wellington, or at the Schools of Mines

GOVERNMENT PROSPECTING DRILLS.

Prospecting drills of various types suitable for the conditions existing in the Dominion are lent to bona fide prospectors. A monthly rental is charged for the plant, and the hirer is required to maintain it in good order and condition, as security for which a deposit is required, together with a bond varying in amount according to the class of drill loaned.

Where the Government provides an expert drill superintendent to take charge, one-half of his salary, together with one-half of the amount of the authorised travelling allowances and expenses incurred while proceeding from his last employment to the site of the drilling operations, and one-half of his camp allowance while the work is in progress, is paid by the Mines Department, but if the hirer provides the drill superintendent the whole of his salary is paid by the hirer. All working expenses are also paid by the hirer, including renewals, etc., and the loss on carbons.

The hirer is required to furnish to the Mines Department weekly reports of boring results.

For boring in rock for coal and oil shale seams or for mineral lodes (reefs) the following drills are available:—

One Schram-Harker steam power-driven diamond drill of 1100 feet capacity; weight, 8 tons (casing excluded).

One Schram-Harker kerosene engine-driven combination diamond drill of 600 feet capacity; weight, 7 tons (including casing). Will drill to 75 feet in gravels by percussion method. Suitable drill for boring lignite or soft deposits.

One Sullivan C.N. steam power-driven diamond drill of 800 feet capacity; weight, 10 tons (including casing).

The above drills produce cores of the rocks penetrated. For boring in gravel or other alluvium for alluvial gold:

Three Keystone percussion traction drills, driven by steam power, of 150 feet capacity in favourable ground; weight of each drill, 9 tons (including 100 feet of 6-inch drive pipe).

One hand placer drill of 60 feet capacity; weight, about 30cwt; can be transported on field by hand labour

Considerable use was made of the Government prospecting-drills during 1924, an aggregate of 5,948 ft. being drilled in fifty-two holes for nine parties, as follows:—

Number of Holes Drilled	Aggregate Depth Drilled	Mineral Searched for	Type of Drill Used	Cost per Foot		Results
				Drilling	Transport	
	Ft.			s. d.	s. d.	
1	1,156	Coal	Diamond	3 9	0 3½	6 ft. coal at 1,149 ft.
1	307	"	"	5 9	1 4	11 ft. 6 in. coal at 293 ft.
1	564	"	"	...	...	Completion of work postponed temporarily.
2	1,356	"	"	...	...	Testing character of country; inconclusive
16	752	Gold	Keystone	.	...	Fair; unfinished.
5	661	"	"	33 11½	3 10½	Good
6	477	"	"	...	...	Poor; unfinished.
17	295	"	Hand Placer	..	...	Fair; unfinished.
3	380	"	Keystone	13 0	2 2	Traces of gold got.

Discussion of Papers

Professor Park (President) in the Chair.

The President: We have twenty-two papers and twenty-eight remits for discussion, and as the time at our disposal is short I hope authors in placing their papers before the meeting will be as brief as possible, bearing in mind that the contents of the papers are already known to all the delegates.

THE PRESENT POSITION OF THE WORLD'S OIL-SHALE INDUSTRY.

By JAMES PARK, Otago University.

Professor Park, in laying his paper on the table, said that as the demand for fuel and power oils increased, the oil-shale deposits of the world would become increasingly valuable.

This being the President's paper, it was agreed that it should not be open for discussion.

Professor Park was heartily thanked for his interesting and valuable paper.

PROSPECTING AND THE REVIVAL OF METAL MINING IN NEW ZEALAND.

By J. F. DOWNEY.

Mr Downey: In undertaking the writing of a paper of this kind, it seemed to me that prospecting was the most important matter that we had to consider at present. All interested in mining know that the industry has been going back for a number of years, and unless something is done there is every possibility that it will die out altogether. I have put forward such suggestions as occurred to me. I do not pretend that they are going to solve the problems connected with the industry, but I have put them forward in the hope that some ideas may be forthcoming that will lead to good results.

Mr T. A. Turnbull: Prospecting is very necessary, especially in a young country. I have been over a great many goldfields, and I know that in the early rushes of the 'sixties men went down the Wairau and other places in the bed of the old river, which came out in Cook Strait. They would sink holes and get very payable prospects. Lots of men threw up work on the coast to go there or to the Wakamarina. I know for certain that there are untouched areas which might be made to yield a valuable amount of gold, but the only way to make sure of the discovery is by a careful geological survey.

Mr J. Leggo: It seems to me that the question brought up by Mr Downey is of too much importance to be allowed to drop without an expression of opinion from the mining representatives

here. We know that metalliferous mining especially is at a very low ebb, and the point we have to consider is how a fillip can be given to that industry. It seems to me that there is no other way than to introduce some sensible system of prospecting. I know that prospectors are just about as rare as poets, and the unfortunate part is that most of the men sent out are men who are looking for bread and butter and an easy job. I think, however, that there are still men to be found with the prospecting instinct—men who would be prepared to go into the bush and carry out prospecting similar to that done by the good old pioneers years ago. It seems to me that, in view of all the gold and all the minerals discovered in the early days, there must be more gold about and more reefs to be discovered, but I think the genuine prospector is just about as difficult to find as the reefs are. We sometimes approach the Government for all kinds of assistance, but judging from the Minister's splendid speech, which was the most comprehensive I have heard for a long time, it seems to me that the Government would be satisfied to help such men if we could find them. I also believe that there are genuine miners among our people who would back up a syndicate, company, or association if we could find those men, and it seems to me that we should try to discover some means to start that sort of thing, whereby men would feel it an honour and a pleasure to go out and discover something, and possibly hand their names down to posterity as the pioneers did in the days gone by. I think it would be a pity to let the subject drop without further discussion. Before I became technical instructor for Nobel's Company, I went through most phases of mining, and I have been spending my money in backing up mining ever since.

The President: The subject is a very important one, and I hope it will not be allowed to drop. Mr Downey has formulated some clear-cut proposals for stimulating prospecting, and I should like to hear members discuss them.

Mr H. L. Tacon: It seems to me that on page 296 of the paper there is a clear-cut scheme proposed. Some such scheme might be formulated here and something tangible done.

Mr P. G. Morgan: I think Mr Leggo has struck the right note when he says that the prospector has to be found. There are only a few true prospectors in any country at any time. I have met a few prospectors, and they are proverbially hard to deal with. Men who want £5 per week are not prospectors, and even those who grumble at 39s per week cannot have the true stuff in them. Real prospectors are so scarce that it is almost hopeless to expect the development of the mineral resources of this country with their aid. The true prospector is imbued with the desire for discovery, and he will go out when the chances are really poor. The old-time prospectors are nearly extinct, but there may be one or two in New Zealand at present, and we should encourage them all we can. It seems to me that the main hope for the future is the employment of up-to-date methods. We must look to our Schools of Mines to train young men who will, I think, be the real prospectors of the future. I think that if the students of the Schools of Mines go out in the summer, when they have finished their course, under experienced men they will probably make some discoveries of importance.

Mr Neil Nicholson: I am very pleased to see such a representation of mining men at the Conference. Mr Downey's paper is a very valuable one. It has been stated that the genuine prospector has gone out. I say he has not gone out. I have every confidence in the industry in Otago and throughout New Zealand, and I am very pleased to see the hearty manner in which you are taking the matter up.

The President: We seem to be agreed as to the need for prospecting and the need for helping prospecting. Mr Downey has put forward a well-defined scheme, and I should like to hear it discussed. Prospecting and new discoveries are the life-blood of mining, and their importance can hardly be exaggerated.

Mr Mance: Your problems seem to differ in no way from ours in Australia. The prospector of the past, who spent the whole of his life searching for minerals, seems to have departed, and if the industry is to go forward we must find new methods. It seems to me that we must apply science and education to prospecting. I agree with Mr Morgan that the best thing to do is to use trained men from the University or geological surveyors to make a reconnaissance of the districts in order to indicate that there are various places in the Dominion that may offer suitable opportunities for prospecting. The methods to be employed have been suggested by Mr Morgan. Science is advancing, and it seems to me that we must ask our young men trained through the University to take up this work. The Governments might assist by offering a career to young men who have passed through the University. In New South Wales we pay up to half the cost of prospecting on any site that offers a reasonable chance of success, but that does not produce the results we would like. We also aid in the work of putting down drills, on which we have spent from £12,000 to £15,000. Altogether we have spent £300,000 on prospecting. Mining is not declining with us, but it needs further encouragement, and I think that assistance should be given by the Governments through their scientific departments.

Mr Kenyon: In Victoria we have perhaps done more in regard to prospecting than has been done anywhere else, but we have never known a real prospector who would go out and work for wages, nor do we know a prospector who would get a share of the results. A prospector works for his tucker, and when getting little more he goes along the hills looking for a reef, which he very seldom finds. I had the honour a little while ago of being a member of a conference which was, perhaps, unique in the Southern Hemisphere—a conference of the geologists of Australia to advise the Commonwealth Government as to the future of the mining industry. A recommendation was made that the geological survey should be extended. That is really the point. By geological surveys you make the way easy for the prospector to examine the country. If you provide tracks as we do in Victoria you will make inaccessible places accessible to the prospector. We have had parties in charge of a Government engineer out prospecting and working for wages without the slightest result accruing.

Mr James Horn, M.P.: Perhaps I have had more to do with applications for prospecting than most men in New Zealand. Many requests to the Mines Department for aid are made

through me, but quite a number are made direct to the Department. I have read Mr Downey's paper with great interest, and I think he has made a lot of new and good points. I have always thought that if the local miner had expert advice he could do much better work than at present. Many of the places to be prospected are far afield and off the beaten track. Mr Downey suggests that practical men should assist prospectors. That is what I want. If you are going to prospect you must have local knowledge. If we could arrange prospect you must have local knowledge. If we could arrange that an expert would go with the local inspector the Department would have confidence in the work done, because the expert would be reporting to the Department. The prospectors could be encouraged by being shown how to work, and the expert knowledge would probably lay them on to something they never knew before. If we get to work as suggested by Mr Downey I think we shall get better results. In the old days the local bodies gave a lot of assistance to miners, because when things were good they got the whole of the rentals for the claims and all the goldfields revenue in the district. All the revenue has now gone, and the result is that when an application is made to a County Council for aid for prospecting the exchequer is depleted. In addition a great many members of the local bodies have no sympathy with miners. That applies in Central Otago, and therefore I say you get no help from the local bodies. Help must come from the Department. If the expenses are paid for two or three months you will get all the prospectors you want, and I believe that a great deal of gold will come to light.

Mr T. W. Rhodes, M P.: I have been associated with mining all my life. My remarks apply to North Island conditions. The South Island conditions are quite different. We deal entirely with quartz lodes or reefs. I believe that we still have a number of prospectors with us.

In my judgment the assistance given to prospectors under the regulations is insufficient to enable men to go out for any length of time in the backblocks when they feel that their wives and families are going without tucker. It is all very well to talk about 39s per week being sufficient, but very often, owing to the interests of his family, a man has to turn to something else. If we can get prospecting going on the lines outlined by the Minister to-day it will be a very different matter, and so far as the North Island local bodies are concerned they are all willing to contribute if any feasible scheme is put before them. We have no difficulty there. Just before the war every local body put up £100, with a promise that more would be put up if it was required. Gold is not found on the surface as it was in the earlier days. There is not the same inducement for men to go out, because men had a better opportunity of finding gold in the early days than they have at present. I think the time has come to induce the prospector to look for metals other than gold. We have a good lot of other metals, and we want to see if we can induce the prospector to bring in samples of anything he does not know and to make use of the Schools of Mines in order to ascertain its contents. The Mines Department is doing a great deal to assist in determining the contents of ore and its value.

Another thing is to try to deal with the low grade ores. We have lodes in more than one part of the Hauraki district, which, according to their value, should be made quite payable propositions. There are areas in the Coromandel district where you can get stuff worth about 30s per ton if you can find the right process of dealing with it. The material would have to be crushed. The ingenuity of man should be able to overcome the difficulties.

Mr R. T. Stewart: I compliment Mr Downey on his very able paper, and the meeting is indebted to him for the way in which he has dealt with the matters put forward. I contend that the rejuvenation of the industry, if it takes place at all, must come as the result of testing the deeper levels, the introduction of new machinery, and the application of scientific methods to prospecting. I believe that the formation of associations as suggested by Mr Downey is most desirable, and I believe that such associations, co-operating with the Mines Department, will do much to revive the industry.

Mr McPadden: The district Schools of Mines have done a great deal for prospectors, and I take strong exception to the statement that instead of reaching out for the prospector and giving him the knowledge he stands in need of, they devoted themselves for the main part to coaching candidates to face boards or examiners. I agree with Mr Downey's suggestion to form a Board, and I think the Schools of Mines should be represented on it. I also agree that local interest is essential. I cannot make out how Dunedin can be in touch with prospectors while we in Reefton are not.

Mr A. H. Kimbell: I wish to add my meed of praise to Mr Downey for the pains he has taken in writing this paper, which is of great interest. I would like Mr Downey to define clearly what he means by a National Association, and to indicate what areas should be prospected in the district under his control. I must join with Mr McPadden in regard to the strictures passed on the district Schools of Mines. I know only too well that the Schools of Mines, or most of them, through their directors and the members of their councils, have given very great aid to prospectors in all parts of the Dominion. The Schools of Mines and the Dominion Laboratory make assays free of charge for prospectors. The Dominion Laboratory imposes a condition that the locality where the samples were obtained must be disclosed. I think Mr Downey was a little unfair, though unintentionally, in his attack on the Schools of Mines. Reference has been made to the methods we have in aiding prospectors in different parts of New Zealand. It is most difficult to know what to do for the best. Our inspectors are required to ascertain the experience of the different prospectors and to find out whether a particular locality deserved prospecting. I am satisfied that they have visited the localities, generally speaking, and have been the means of giving expert advice over and over again. With reference to Mr Horn's remarks, I may say that the whole of the mining revenue payable by people holding claims and other mining privileges is credited to the local bodies. If the local bodies in Mr Horn's district are not prepared to help mining, is he prepared to support any amendment in the House to enable that revenue to be credited to the Mines Department? We shall have very much pleasure in helping him to spend it.

Mr J. B. Auld: I wish to congratulate Mr Downey on his excellent paper. We greatly appreciate the assistance which the Mines Department has given us in the Reef-ton district. We also appreciate the assistance given to us by Mr Downey and the Geological Survey Department.

Mr Downey: I think the speakers have agreed that more prospecting is necessary, but nobody seems to be satisfied about the manner in which that prospecting is to be carried out. I have tried to make some suggestions, and mentioned something in the way of a National Association. Reference has been made to the payment of prospectors. I do not think the genuine old prospector is a thing of the past. I believe that under certain conditions we could get men to do the work, but we may not get them at the present schedule rates of subsidy. My idea was to form provincial or local associations, which would enable men to go out and get something like a living wage. By a National Association I meant the formation of something that everyone could support. It might be only a matter of putting up £1, £5, or £10. I believe that in New Zealand we can get sufficient men interested in mining to put in £8000 or £10,000 between them. Surely there would not be great difficulty in arranging that. That would enable us to carry out a great deal of prospecting, which would be done under the direction of competent men. I suggest that the men under the control of a National Association would be men of standing in the mining world—trained mining engineers to a large extent. Men giving financial support to such a scheme would be satisfied, knowing that in the spending of the money there would be good guidance, and that they would get a run for their money. I think that at such a Conference as this a body could be formed representative of all parts of New Zealand. I think that if it is possible something on the lines I have suggested should be done. I think Mr McPadden has taken me rather the wrong way. It was not in my mind to disparage the work of the district Schools of Mines, as I know the valuable work they have done. What I meant was that it did not seem that the Schools of Mines made any special effort to give what I might call special lectures to prospectors. I think we should make an effort to see that the men going out have a better mineralogical knowledge than they have at present. It is very gratifying to know that the paper has aroused so much interest, and I hope some good will result from it.

The President: Mr Downey's proposals are covered to a very large extent by a remit. It is our intention to set up a Committee to deal with all matters of importance raised at the Conference, and the points mentioned by Mr Downey will receive most serious consideration.

NOTES ON THE AMERICAN TYPE OF DREDGE OPERATING AT RIMU FLAT, HOKITIKA DISTRICT.

By J. F. DOWNEY.

The President: I have much pleasure in asking Mr Downey to place his paper on the table.

Mr Ford: Mr Downey has described the machinery and equipment very thoroughly. The first dredge we had in California came from Otago, but it was not heavy enough. The company scrapped that dredge and built another one, and so things went on until a dredge of this type was developed. We have had troubles, but have been able to handle considerable ground.

Mr W. F. Sligo: I think this paper is of very considerable interest to the people of Otago in particular. The dredging boom started here about 25 years ago, and there were hundreds of dredges on the rivers and flats. Although a great deal of gold was won, there were many failures. I went over to Rimu Flat after it had been taken up by the first American syndicate, and after examining the ground I came to the conclusion that there was no chance of any dredge we had in New Zealand handling the material. The Sandy Point dredge was put on the claim, but I maintained that it could not work the ground, and that proved to be the case. Many of the failures in Otago were attributable to the fact that the machines were incapable of doing the class of work required. I am sure there is room on the Molyneux for a dredge like the Rimu Flat dredge. The returns got by the Golden River dredge showed that the values were there. It was only a question of power, which was not available. I do not think it was altogether the fault of the engineers, because the companies were formed with a limited capital. The difficulties in getting coal on board were very considerable, and tended to break down the industry. Electric power is now available from Roxburgh to Cromwell, and there seems to be considerable inducement to give the Molyneux another trial with a dredge like that working on Rimu Flat at present.

Mr J. R. Leggo: I had the pleasure of visiting the Rimu Flat dredge, and I can honestly say it is a very fine piece of machinery. The great thing done for New Zealand is that it has shown how the proposition should be tackled. If a New Zealand company had tackled the Rimu Flat proposition and had asked for £120,000 I doubt whether it would have got the money in this country, and if it had got it I doubt if there would have been an engineer in New Zealand who could have designed a dredge of such capacity. This is one of the finest examples of how a difficult proposition should be tackled. The American people evidently sent engineers with instructions not to fool their employers and not to fool themselves. They guarded against under-capitalisation, to which Mr Sligo has referred. I believe the Rimu Flat dredge is paying quite nicely at present.

The President: The dredge is certainly a real object lesson to us, and one of great value, as showing how difficult ground may be successfully worked.

Mr Downey: There is no doubt that the putting on of the dredge has been an object lesson to the people of this country. Great courage was shown by the company in tackling the pro-

position and going to such a large outlay. The American engineers have shown us that, provided a job is tackled in the right way and the right sort of plant is put on very poor and very difficult ground can be handled. I daresay there are other places on the West Coast where we shall have similar dredges in the future. Otago is another place where dredging is likely to be revived on a large scale. The information in the paper will be of considerable value to those engaged in the industry.

SOME ESSENTIALS FOR SUCCESSFUL OIL DEVELOPMENT.

By FREDERICK G. CLAPP.

The President: In the absence of the author Mr Kimbell has consented to introduce this paper.

Mr A. H. Kimbell: Mr Clapp spent about twelve or eighteen months in making a detailed examination of several parts of the Dominion for the purpose of advising a strong financial company in Australia as to what it should do in trying to prove our oil resources. He is one of the recognised oil geologists of the world. Unfortunately he was not able to spend as much time as he desired preparing the paper.

The President: I have read this paper with great care, and I consider it is a useful exposition of the development of an oilfield, especially a potential oilfield. He has described the criteria in a most lucid manner. In some American oilfields the geological conditions are totally different from those existing in New Zealand. In the mid-Continental oil region in America the rocks consist of a great succession of shales, sandstones, and limestone of very great antiquity. They dip towards the west, but they lie so flat that it is only by the most exact instrumental determination that the dip can be ascertained. The dip ranges from 4ft to 20ft to the mile, and, looking at a section in a creek bed, one would think, judging by the eye, that they are perfectly horizontal. There occur little humps or domes, and it is in these that the oil has accumulated. The chief work of the oil geologist is to discover the sites of these minor corrugations.

Mr Turnbull: I have had some experience in regard to oil examination. When the Industries Commission came round about five or six years ago I brought forward the question of boring for oil, and I strongly urged that no bore should be put down until a site was examined by a Government geologist or some competent person, so as to prevent "wild cats."

Mr P. G. Morgan: I have only glanced over the paper, and am not able to discuss it in any detail. Mr Clapp puts the case well as to what are essential conditions for successful oil development. He considers that New Zealand offers successful conditions for oil development, but that does not mean that the country will necessarily produce oil. I agree that New Zealand is likely to produce oil in commercial quantities, but it has not done so yet, and one cannot tell whether it will do so or not. Some oil has been produced in the Taranaki district and elsewhere, and there is no doubt that more will be produced. I think the New Zealand oilfields will be found for the most part to be rather small, and that in various ways the conditions will be difficult. Every precaution must be taken not to waste money

in boring. So far nearly all the money spent in boring has been wasted. Hardly a particle of useful information has been got in the Gisborne district, and the results of the bores have been absolutely negligible. In order to avoid the mistakes of the past the first thing to do is to seek the advice of competent and experienced geologists. The necessary capital has to be found, and that capital must be wisely expended if the oil industry is to be successful. There are competent geologists at present, both in the Department and out of it. I think there need be no fear about the geology being adequately attended to. Oil may be struck somewhere in a few months, but it is more likely that it will not be struck within a year or two. It may be that half-a-dozen or more bores will be sunk before successful oil production comes in.

The President: I am very hopeful that profitable oil will be found to the west of Waiotapu by boring in places selected by oil geologists.

Mr J. Horn: I wish to propose a hearty vote of thanks to Mr Clapp for his paper. I have seen indications of oil in Taranaki, and indications that were very strong in Gisborne. It is very disappointing, in view of the money spent in the Poverty Bay district, to find that we have not struck oil already. The first boring was done there in 1881. I spent a fortnight in a tent at the lagoon alongside the bore. Bubbles were coming up constantly, and barrels of oil could be skimmed off the lagoon. It will be a very fine thing for the country if oil is found.

The motion, which was seconded by Mr Kimbell, was carried by acclamation.

SHORT ACCOUNT OF THE SEARCH FOR PETROLEUM IN EGYPT.

By H. T. FERRAR.

The President called on Mr Ferrar to present his paper.

Mr Ferrar: My reason for presenting this paper to the Conference was to give a few facts in regard to the development of the industry in a new country. I have not touched on costs, because they have changed so much since the war. The search entailed a visit to large areas of desert. Unfavourable areas were eliminated, and by means of the geological survey the Government was able to concentrate on promising areas. The table at the end shows that the ratio of dry holes to producing wells is about seven to one. That will give some notion of the cost of opening up a new oilfield area.

SECTIONS OF COAL MEASURES KAITANGATA COALFIELD.

Mr Ongley: There are two series of coal measures which are unconformable.

Mr P. G. Morgan: Mr Ongley clearly states the main point—that in the Kaitangata-Milton district there are two systems of coal measures which are unconformable. Not only has there been material erosion between the two sets, but the earlier set has been tilted and faulted, probably before the newer set was deposited. Unconformity has different meanings to different people. So long as in any considerable portion of a field there

is a discrepancy between the types there is unconformity in the strict sense of the word. In any case there is no dispute so far as the officers of the Department are concerned. An old geologist, Sir James Hector, maintained that practically all the coal in New Zealand was to be found in one series of rocks, those of his Cretaceo-Tertiary age, but the work done during the last 15 or 20 years has shown conclusively that the coal is of more than one age.

The President: I agree that there are two separate coal measures, but Mr Morgan is mistaken in saying that Sir James Hector regarded all the coals as belonging to one age. Sir James Hector showed conclusively that the middle Tertiary Oamaruan coals lay unconformably upon the Senonian Shag Point coals. I have very much pleasure in moving a hearty vote of thanks to Mr Ongley for his very useful paper. The paper will be very valuable to mining men later on.

Mr Ongley: Professor Park is not agreeing with me. As a matter of fact I am agreeing with what he wrote many years ago.

PROTECTION OF UNDERGROUND ROADWAYS.

By E. S. WIGHT.

Mr Wight: I shall be pleased to demonstrate the work done at the colliery to anyone interested. The object in writing the paper was to help the Conference along and to show that we have been instrumental in using the cement gun for the protection of airways. There is no doubt that at a certain period the airways were subject to a great deal of fretting. We have now done some 3000 lineal yards of airways, and we are satisfied that the protection is warranted. A good many who are interested have visited the mine, and I think they are pleased with what has taken place.

Mr Bayne: I congratulate Mr Wight and the Pukemiro Coal Company on the enterprise shown in the new method of protecting the roadways. There is no doubt that it has been a great success at Pukemiro. Prior to the introduction of this method the pillars were fretting very badly, and it was apparent that that would continue until they were seriously weakened. A considerable amount of guniting was done, with complete success so far as the stopping of fretting was concerned. I strongly recommend people to visit Pukemiro, because this method is capable of successful application in other mines in the Dominion.

Mr Wight: There is a very marked improvement in the light. Going through the mine resembles going through a quartz drive.

Mr Horn: What effect would this have on fires in mines? Would it help to extinguish fires or seal them up?

Mr Wight: That is a matter of the conditions existing at the time in connection with fires, but it would certainly assist in this way, that if you had stoppings erected it would assist to make them airtight. There is no direct strength in guniting; it will not resist pressure. It is merely a protection against atmospheric conditions.

Mr Kimbell: Does the cement break away very much?

Mr Wight: No. The work is not breaking away. It is standing up very well. The Waikato coal is very hard, shiny, and glossy, and there are places where the cement is not adhering so well, but that applies only in a few places. In these operations we have gone through headings, faults, fire-clay, and so on. I do not think the cement would adhere properly in fire-clay drives, but it would adhere in rock drives. There is, however, no necessity for it there. You must timber in a fire-clay drive in our colliery.

The President: I think you will agree that we should compliment the author of the paper for introducing into New Zealand an effective method of dealing with coal mine roadways. This is a matter of extreme importance, and Mr Wight has certainly shown very great enterprise.

THE TREND OF MINING LEGISLATION IN NEW ZEALAND.

By ROBERT GILKISON.

Mr Gilkison: There are three directions in which the legislation on gold mining has been much altered in late years. The first is as to larger claims. In that way capital, which is absolutely necessary for the working of the ground, is encouraged. In the second place I have pointed out that irrigation had to be provided for. That is a very large subject, and the beginning of irrigation depended altogether on our Mining Act. In the third place I pointed out how the Minister's powers have been extended in New Zealand. A remarkable thing is that they are not only administrative but now they are beginning to be judicial. Certain claims cannot now be forfeited unless the Minister consents. In a hard-fought case it would mean cases in the Warden's Court, the Supreme Court, and lastly before the Minister, but the Act does not say what the Minister has to consider or how he is going to do it. It will not do to listen to one side one day and to another deputation the following week. He must make the people come and have the whole thing out before him, whether it takes a day or a week. I am referring to cases where the Minister's consent is required for a declaration of forfeiture.

Mr Kimbell: It applies only to water rights.

Mr Gilkison: I think it refers to any claim that is subject to tribute. As regards water rights, these are applications, and the same rules should apply. The Minister should not hear one side privately and the other afterwards, but should hear both together. I find that I made a mistake in discussing the Kawarau dam. At the foot of page 274 I stated that the Warden did not grant the dam without the approval of the Minister. The application was referred to certain Government engineers, and did not require the consent of the Minister.

The President: On behalf of the Executive Committee and the members of the metalliferous section of the Conference I wish to say that we are very much indebted to Mr Gilkison for his very able paper. Mining legislation is recognised as being amongst the most difficult of all in connection with the industries of New Zealand. It is very complicated. The Mining Act has been amended a great many times, and under the main Act and the amending Acts regulations have been put into force by

Order-in-Council. It has been almost impossible for a layman to follow the trend of the legislation, and for that reason the Executive approached Mr Gilkison with the object of getting a condensed account of the present trend. Mr Gilkison is the author of a standard work on mining legislation. His work is recognised throughout New Zealand as the authoritative text book on that subject, and it was for that reason we approached him, knowing his great qualifications to carry out this work thoroughly. I hope there will be a full discussion on any points requiring attention. I am glad that Mr Kimbell, Under-secretary for Mines, is here. Proposed amendments of the Act naturally come before him, and for that reason he is in a position to exercise a powerful influence on the trend of mining legislation.

Mr Kimbell: I would like to convey to Mr Gilkison my hearty appreciation for his action in writing this valuable paper. You will appreciate the value of it when you realise that Mr Gilkison is the author of a very interesting text book on mining legislation in New Zealand. I would like to suggest that Mr Gilkison should bring his text book right up to date after the Mining Consolidation Bill becomes law next session. I propose to make a few comments on some of the statements made by Mr Gilkison and I do so in the friendliest way possible. On page 270, under the heading of extension of power of the Minister, Mr Gilkison stated:—"The following is the substance of the conditions which have recently been imposed by the Minister on the license for a small special alluvial claim on the banks of the Kawareau River." He then goes on to refer to the placing or a suitable dredge on the claim. I suggest that you should reconsider that clause before the paper is finally printed and circulated.

Mr Gilkison: The word "plant" should be used instead of "dredge." I think the word "plant" was used by me.

Mr Kimbell: The conditions you have given are not a correct repetition of what is required by the Minister. In all cases we have not put the conditions in as you have worded them. On page 271 there is another error. You refer to a dam or water race for more than 20 heads. In the Amending Act of 1919, Section 2, the 20 heads were reduced to 10. In the next paragraph you state that the consent of the Minister generally means the consent of the Department. I have worked under three Ministers, and I do not think that is a very fair statement to make. All the Ministers I have worked under have exercised their discretion. They expect me to advise them as to what course should be adopted, but they exercise their own discretion, and what they say must go. There is another correction on page 273, where the words "20 heads" should be "10 heads." Personally I welcome your criticism in a friendly way. It is only by just criticism that we can take advantage of men who are skilled in mining law or mining, and I am sure that feeling is not only my own, but that of the whole staff. With reference to Mr Gilkison's remarks about forfeiture, I may say we have not had a case yet, and I feel certain that if we have one the matter will be dealt with in a just way, having regard to the public interest. Mr Gilkison expresses some opinions on how legislation is prepared. The origin of all mining legislation arises out of comments made by wardens, lawyers, unions, and anyone interested in mining. They write from time to time,

and we take notes of the comments. Once a year we go through the book and put the whole position before the Minister. He states what he is prepared to do, and we get into touch with the Crown law draughtsmen and explain what is wanted. They then prepare Bills, which are introduced and referred to the Goldfields and Mines Committee, which goes exhaustively through the legislation. Those interested are given every opportunity of expressing their views, and nearly every session all sorts of people give evidence as to what they think should be done. If people think they are not getting a fair deal they might get a man like Mr Gilkison to go to Wellington, and we shall be very pleased to see him up there. I have found it very difficult at times to know what should be done. There are some very astute people, who are out to make the most out of mining, and we have to keep our wits about us to know what to do. We have letters to the Minister congratulating him on what has been done to protect the mining industry, and while I am where I am now that is going to be my objective.

Mr Nicholson: I think Mr Gilkison knows more about mining law than anyone else in New Zealand. Small claims, say, two or three acres, used to be granted by the Warden's Court without any trouble, but now such matters appear to have to go before the Minister.

Mr Kimbell: Where a claim is under 30 acres the application does not need to go before the Minister.

Mr Nicholson: I think the area should be enlarged. Sometimes there has been a delay of two or three months. A man might take up a prospecting license over 50 acres, and if it is granted by the Warden he might spend £2000 in prospecting. The Minister and his officers are most conscientious, but we never know what is going to happen. I think that is one of the things that could have been left out. It was once possible to take a prospecting license over areas from one to 20 acres, but now a poor man cannot take up less than 20 acres.

Mr Kimbell: There is one over 15 acres.

Mr Nicholson: He has to pay £1 for it.

The President: No one doubts the sincerity of the Mines Department in its desire to promote prospecting. The Department is doing what it conceives to be the best for the industry, but it is our duty to stir up the Department occasionally, because Government Departments sometimes suffer from a kind of inertia, which is very difficult to overcome.

Mr Sligo: There is one aspect of company law to which I would like to refer, and that is in connection with new flotations. Take the case of a number of men who have worked a mining property for many years and who require more capital. Their idea is to form their small concern into a company, but they are the vendors of that property, and the vendors of a property may not subscribe to the memorandum of association or have their names in the prospectus. The result has been that the vendors really have to employ dummies to sign the memorandum of association and the prospectus until a new company is formed. That

is causing considerable difficulty with new flotations. The vendors of a property must know more about it than a new entrant into a company or a subscriber. I know that dummies have to be employed to sign prospectuses and assist in the flotation or a company. It is very objectionable that we have to do that.

Mr Kimbell: That comes under the Companies Act. That objection, or a similar one, was raised six or eight months ago. A practical miner who had spent money in improving a claim and who desired to promote a company could not become a director of that company. I took the matter up with the head of the Stamp Department. They tried without success to find out the origin of the Act, which has been in operation for 40 or 50 years. We have asked the Stamp Department to repeal that particular section in the Companies Act when the next Bill is sent to Parliament for consideration, and they have promised to do that.

The President: One remarkable circumstance in connection with the New Zealand Companies' Act is that anyone with a dummy can promote and float a company, and can put after the title of the company, the word "Limited," and that without registration, which is very liable to mislead the public. I think our Act should be put on all fours with the English Act.

Mr Kimbell: I have noted in a great many cases in Otago and several other parts of New Zealand that the vendors' names are not given in a prospectus. People are referred to some agreement in some lawyers' office. The names of the vendors should be given in the prospectus, and the full consideration should be given. There should be some means whereby those making statements in a prospectus should certify as to their accuracy—(Hear, hear).

Mr Gilkison: I thank you for the way you have received this paper. I am glad to see that the subject of legislation interests all who are connected with the mining industry. I thank Mr Kimbell for the suggestion to bring out a second edition of my book on mining law, but there is so little demand for works of that sort that it does not pay. If the Government will undertake to print the book I shall be very pleased to supply the matter.—(Applause). There was no profit from the first edition, and there was a much larger sale than there would be now, so that a second edition would result in a loss. As to the conditions in regard to special alluvial claims, I condensed that part of my paper from a full copy of the conditions which I received from a responsible person, showing what had actually been done. I shall be glad to show that to Mr Kimbell. I said that the consent of the Minister generally meant the consent of the Department, and I think I was only making an inference of common sense. We have one Minister in New Zealand, with his hands full of many other things. Mining is only one of many portfolios, and how can he possibly attend to applications for every dam in New Zealand. Here and there a matter of policy will come forward, and no doubt he will decide that for himself. By using the word "generally" I meant to refer to ordinary matters of routine which are so small that they must be decided by the practical men and the head of the Department. The question raised by Mr Sligo has not been considered in my paper. It is a very big question, and one which would very well stand dis-

cussion. It is a pity we did not have a paper on that as well. The Minister has referred to that, and I can see that we are on the verge of new legislation, which is very much required. Whatever legislation is passed it must refer to prospectuses. Forestry prospectuses are just as much at fault, and some of the very worst frauds perpetrated have been in connection with land cut up for fruit-growing purposes. There is wickedness spread over every industry, and a tightening up of the legislation is much required.

Mr Sligo: I move a hearty vote of thanks to Mr Gilkison for his fine paper.

Mr Kimbell: I second the motion. I feel sure that Mr Gilkison has put an enormous amount of work into the preparation of the paper. We probably cannot realise the pains taken in compiling it, because the existing law really is a monstrosity. This paper will be of very great interest to those interested in mining, and I wish to convey to Mr Gilkison the appreciation of the Minister for the generous offer to prepare a second edition of the book.

The motion was carried by acclamation.

BIG BLASTS WITH WELL-DRILL HOLES AND TUNNELING.

By JOHN R. LEGGO.

Mr Leggo: This paper is the result of an endeavour to show the most economical way of dealing with big quantities of material, such as ore, metal, the removal of hills, and anything of that sort. I think tunnel blasting, as compared with shorter holes or ordinary drill holes, will be found to be more economical and more effective in big blasts, because we have the full energy of the power of the explosives, whereas with smaller shots they are so small that very often you do not get the benefit of the full energy given off. At the end of the paper there is a description of a blast about to be carried out by the Wilson Cement Company. Their system of blasting is drilling very deep holes, varying in depth from 120ft to 240ft or 260ft. The size of the holes is 5½in, and the cartridge is a special one of Nobel's make, 5in in diameter. We have to provide a strong cord or fishing line, by which we can lower these cartridges, which weigh 25lb, to the bottom of a hole, otherwise the friction would start them off. Instead of firing these shots by means of ordinary detonators, they are using what is known as the Cordeau-Bickford fuse. This is one of the finest things I have known in late years. It is charged with T.N.T., and the speed of detonation is 17,500ft per second. The advantage of this over the ordinary detonator lies in the fact that if you have alternating strata of soft and hard material you can so place your charge that it will be in the hard stratum and your tamping in the soft stratum. There is another very great advantage, and that is that you are firing your shot from the collar of the hole instead of having the detonator smothered and covered by many feet of tamping, so that in the case of a missed shot there is no necessity to interfere in any way with the shot. That is a very fine advantage. This fuse gives the explosives a wonderful fillip. It is a booster, and eliminates the chance of burning, which would very often occur in the firing of big shots

like we are doing at present. It seems almost contrary to reason but it is a fact that in a very long hole the continuity of the wave gradually dies out. You would think it would intensify, but it does not. Possibly at the bottom of the hole you find a fair percentage that is practically wasted. This fuse does away with that.

The President: Mr Leggo is a highly qualified expert in the matter of explosives, and his paper will be read not only with interest, but with profit. I shall use it very largely for my young engineering students. I thank Mr Leggo very much for his kindness in writing the paper for us.

Mr W. R. Smythe: On page 222 we have a diagram showing the mode of putting in cross drives. We have adopted that method, but one thing that struck me was this: For the sake of safety you must put in a main drive before you can start cross-driving, and there is a little time wasted before you can put two sets of men at the cross-drives. Does Mr Leggo think it would be a disadvantage if two drives were put in at the face and two charges were put in? These two charges could be put in simultaneously. I would like to ask Mr Leggo if he thinks it advisable in a block of ground that simply wants to be given a shock to divide the area with a cross-drive and put half a charge in each end and a heavy charge right in the centre.

Mr Banks: I have had no experience with big shots such as those referred to in the paper. We frequently have the experience that portion of the charge is not detonated and is picked up in the rock after the explosion. If it burns it is also bad. I have usually come to the conclusion that that was due to improper loading of the hole, and I think that by more careful loading on the part of the miners there would not be much of that. It is a most important point. Apart from the loss of material there is a danger of unexploded material getting amongst quartz and causing an explosion afterwards.

Mr Downey: I would like to add a few words of appreciation regarding the excellence of the paper. The only regret I have in connection with it is that it is not appealing in a large way to people who are more interested in large blasting than those attending this Conference. I think it might perhaps have added to the value of the paper if Mr Leggo had given us a little more information about the number of large blasts fired in New Zealand in late years especially in regard to the matter of costs. The use of big blasts is beginning on the West Coast. I notice that the cost of a blast at Mosgiel amounted only to the small sum of 2½d per cubic yard. I think quarrying is allied to mining now, and it seems to me that it would have been appropriate if the quarry owners had been invited to this Conference. I think it would be a good thing if this paper could be brought under the notice of those people. The cost is generally very much higher than 2½d. A paper like this, giving the cost, would be of very great interest to municipal and other public bodies of many kinds, in addition to the man in charge.

Mr Whitley: I congratulate Mr Leggo on his valuable paper. When it is circulated I think it will be very useful to the quarry owners of Otago. If the Lawrence cements could be broken down for 2½d per cubic yard probably the owners could make it

payable proposition if the values are as stated—6d per cubic yard. I am satisfied that if the system of big blasts were adopted it would considerably reduce the cost of quarrying stone in most of the big quarries throughout Otago.

Mr Leggo: In regard to two tunnels for one blast, it is preferable to have one tunnel at a cross-cut from the main drive, because your explosives are thoroughly covered and enclosed, leaving no possible chance of expanding energy like through the barrel of a gun. I have in mind a terrible disaster in a Government quarry at Ohakune, where a shot was put in with the chambers at the very end of the quarry, like cartridges would be in the breech of a gun, but unfortunately in testing the continuity of the current they used two dry cells. The power in these cells was sufficient to fire 50 holes, with the result that five men were killed. One man's remains were never discovered. I would strongly recommend one drive and a cross-cut from there. As a rule this can be done while other work is going on, unless you are waiting entirely for the big shot. Furthermore, it is a good thing to have a section of porous concrete absolutely bottling the explosive in its position. With reference to some explosives not firing I may say that the continuity of a wave gets weaker the further it goes, and when it becomes a case of firing through heat, high explosives will explode suddenly when in contact with heat equal to about 1750 degrees Fahrenheit. Very often there is only a little stuff left that has had time to do its work. Sometimes burning is due to overcharging, and at other times it is due to careless charging. At times explosives are not of the same sensitiveness. There is so much nitro-glycerine poured into the tub, and it is quite possible that a few plugs have not got the percentage they should have. We have fired a great number of shots lately, and the last shot panned out at about less than 4d. We have had, I suppose, 100 big blasts within the last five or six years. It is only recently that these big blasts have become so popular, and I am sure that people engaged in procuring metals or minerals in big quantities will find it very suitable. It is not, of course, suitable for all classes of work. In reply to Mr Smyth's question, I would advise a division into two blocks. We are going to fire a shot at the Arapuni deviation tunnel, and we have to shift what engineers call a dumpling containing about 3500 cubic yards. The stuff has to be so crushed up that the river will carry it through the deviation tunnel. I am quadrupling the ordinary charge to make sure that the stuff will be carried through by the water. I am charging kerosene tins full of explosives, and in each I am putting three detonators. We shall fire scores of tins, and shall take the "juice" from the main line. We hope it will be a success.

Mr M. Paul: When the quarry owners know what can be done by explosives and the cheapness of explosives the company will be doing good business.

THE MINING INDUSTRY IN NEW ZEALAND AND THE STATE AID AND REVENUE.

By A. H. KIMBELL.

Mr Kimbell: This paper speaks for itself, but I would like to stress the statement that from January 1, 1875, till March 31, 1925, the revenue paid by the Government to local bodies in respect of goldfields revenue and gold duty was £3,706,234. It is my intention to keep this going from now and to keep the information up to date.

The President: The paper is a very useful one. It contains the kind of statistics which one very often wishes to refer to.

Mr J. Horn: Probably I come in contact with Mr Kimbell and the Minister as much as any other man in the House. On the whole I think the Minister is sympathetic, and so is Mr Kimbell and his officers. Very often we do not get what we want, but we get a "slice of the bacon." Mining was put in an awkward position when after the war the export of gold was resumed. Last year I saw the principal mines of Western Australia and also the principal mines of South Africa, and came in contact with all the men. They all got a bonus on their gold from the time the restriction was put on until it was taken off, which we never got in New Zealand.

Mr Kimbell: It was not a big one.

Mr Horn: That, in my opinion, was a set-back, from which it will take years and years to recover. We had that question before the House. First, the blame was put on the Associated Banks, then on the Government, and finally on the Imperial Government, but we never got satisfaction. We tried hard to get a bonus. While wages increased and the cost of material increased 200 or 300 per cent. we never got anything, but in Australia and South Africa the restriction on export was taken off about nine months before it was in New Zealand, and it was during those nine months that the high price was got for gold. We have it on record that just on £7 per ounce was paid for gold, while we were getting £3 17s 6d in New Zealand. I think that owing to the strong case that was made out the Minister of Mines has opened his purse to a slightly better extent than previously, and I think it is recognised that the Government must help mining better than before. I hope that will continue, and that we shall get more money for prospecting and otherwise than we have been getting.

Mr Banks: The embargo on the exportation of gold was not lifted here for many months after it was lifted in Australia and South Africa. If the Waihi Company had been able to take advantage of the maximum price nine months or so earlier it would have represented an increase in our selling value of about £140,000. The serious part was that during the war our costs increased very considerably, and until we were able to take advantage of the higher price we were at the disadvantage of paying an increase of about 60 per cent. in wages and stores. For 600 men that meant a very big thing. We know the Government of New Zealand got no direct benefit from that, and I think the banks got no benefit. I suppose the Home Government got the gold, but it got no actual benefit. The benefit we would have got would have been in selling the gold to advantage in London to meet the position of the high American ex-

change. In Western Australia lately they have been considering the question of a bonus for the production of gold. That is a thing which might be well worth considering as a means of stimulating production in New Zealand from new districts and new mines. One can hardly say that it should be employed in the case of the Waihi mine, where we are making a handsome profit and have a long life. I do not see that a bonus should not apply in the same way as the Government offers a bonus on quicksilver, iron, and so on. I think we should have an opportunity of discussing it.

Mr Auld: I wish to congratulate Mr Kimbell on his valuable paper. It is principally statistical, but statistics are valuable. We cannot help being struck by the magnitude of mining and the important part it has played in the prosperity and development of the country. We must also acknowledge the valuable assistance given by the Department. Independent of the geological survey, £1,878,628 has been spent by the Department on metalliferous mining in one way or other. The sum of £11,272 has been spent on the geological survey, making close on £2,000,000 in assistance towards mining. In the South Island £3,000,000 has been paid in goldfields revenue. Does that include royalties from timber taken from reserves? Four-fifths of that revenue is taken from us under the Mining Act, and it should be given to us.

Mr W. R. Smythe: I must congratulate Mr Kimbell on the amount of valuable information he has got into this paper. The local bodies have secured something like £3,500,000, and the amount spent by the Department is close on £2,000,000. Supposing it had been in one Department, the exchequer would have been over £1,000,000 to the good. The country is reaping a tremendous asset from the work done for the mining industry by the pioneers.

Mr Sligo: I am very pleased that the question of the Government confiscating the gold during the war has been referred to. We made quite a good fight some years ago in the endeavour to recover something. There is no doubt that those running mining claims at the time had a very hard row to hoe.

Mr Auld: I shall draw the attention of the dairying people to the fact that the Mining Department is giving them access to their farms, and the timber on many farms has been cleared, thus giving them a better opportunity of developing their land.

Mr Kimbell: The figures I have given do not include all timber royalties. As to the legal position attaching to whether the local bodies should get that money or whether the State Forests Department should retain it I cannot tell you offhand. I have not been following closely the recent trend of State Forestry legislation. I know that the amount spent by the Government and by the local bodies out of mining revenue will endure for many years. We took over a mining race at Roxburgh which cost a mining company about £76,000. The race was handed to the Public Works Department, and then to the Power Board. The water is now being used for power, and the energy is being distributed, and the water is then used for irrigation. I venture to say that most of the bridges in Central Otago come out of goldfields revenue or from the Public Works Department. People are very apt to forget what they owe to the Mines Department and what mining has done for New Zealand.

Mr Smythe: I move a hearty vote of thanks to Mr Kimbell for his valuable paper. I think it is a very important one. I think we have enjoyed it, and that we shall be able to make very good use of it.

The motion was carried with hearty applause.

BOILER WATER: ITS COMPOSITION, EFFECTS DURING USE, AND ITS TREATMENT.

By D. B. WATERS.

Professor Waters: This paper has been written with the object of bringing out the effect of different boiler waters. At the end of the paper I have made some suggestions. During the last three or four years a number of people have brought samples of boiler water to me, and have asked what was to be done because the water was giving them trouble. I would advise all those who are using water for boiler purposes to have it analysed and reported upon before they use it, in order to find out what effect it will have. I know that in different instances in Otago I have helped people in that direction. When you have a number of water supplies it is well to know which water is the best and which is the second best if the first supply runs dry. I hope this paper will be helpful to members of the mining community and enable them to see what should be done in regard to boiler water.

Mr Wight: I would like to say a little in corroboration of Professor Waters's remarks. The water we have been using has been very hard, and has been making a heavy incrustation in the tubes. We sent samples for analysis, and treatment on the Larsen retort principle was recommended. We installed that plant, and the result has been very successful. We reduced the hardness of the water from 13 to about 2½. It is a treatment in which we use unslaked lime. It is very simple and very cheap. It is automatic, and according to the amount of water used a quantity of lime is supplied, so you cannot get too much or too little. We have saved a great deal in labour in cleaning tubes. I recommend anyone who is troubled with boiler water to carry out Professor Waters's suggestion and have the water analysed.

Mr W. Donovan: One point which I would like to stress is corroding, due to gas. I have not known of this in boiler water, but it has occurred in hot water systems. Most waters contain a certain amount of dissolved organic matter. The failure in many hot water systems is due not to scale, but to the formation of acids. I think this is one of the finest reports on boiler waters that it has been my pleasure to peruse.

Mr Bradley: I think we have got something we have been long looking for. In connection with hydraulic plants we are in the unfortunate position of having to use water. In dry weather the water is very foul, containing acids and iron salts as well. We have adopted a primitive system of overcoming the difficulty by drying out with lime. It is very crude, but it is having a beneficial effect. We have no great catchment area, and have to conserve what rain water we can get. We are

suffering great loss from corrosion. Our sincere thanks are due to Professor Waters for his very valuable paper. I am very thankful for getting it before us.

Mr A. Gillanders: During my long experience with mines and other things I have seen boilers badly used through bad water. At Shag Point we were depending on water which was absolutely salt. From one boiler we took 14 large barrels of sediment. It cost a large amount for repairs, and no sooner was one boiler repaired than the other was done. That occurred three times. That shows the importance of having water treated, and knowing how to treat it in the first place. If we had known sooner how to treat the water we would have avoided a huge expense. I wish to thank Professor Waters for his most valuable paper.

The President: I think we all agree that the paper is a most useful one. It will be appreciated by professional engineers and also by students. It is a condensed text book on the subject.

Professor Waters: I wish to thank members who have spoken for what they have said. I consider that every boiler compound should be required by law to state on the label what it contains, because some of them are 99 per cent. water, and others contain a large amount of silica and other harmful things.

The President: I move a hearty vote of thanks to Professor Waters. I wonder if you realise the difficulties under which he worked when he wrote the paper. He was a very sick man indeed, and he showed great courage in writing it in order to have something on record for us.

The motion was carried by acclamation.

THE AURIFEROUS OR CONGLOMERATE CEMENT DEPOSIT OF THE TUAPEKA DISTRICT, OTAGO, N.Z.

By WM. R. SMYTHE.

Mr Smythe, introducing this paper, expressed pleasure at being allowed to do so. The point he wished to make, he said, was that only a small amount of the huge area of auriferous conglomerate existing around the districts of Blue Spur, Wetherstones, Paddy's Point, Glenore, and Adam's Flat, had been worked, and although some £5,000,000 worth of gold had already been won the quantity had rivalled, if not excelled, that of any auriferous deposit in the South Island. It had been estimated that near Wetherstones alone some 413,000,000 cubic yards awaited treatment, and allowing a conservative return of 6d per yard this in itself would yield over £10,000,000.

In referring to the treatment of the cement in the past, Mr Smythe said that the method that had been generally employed was the stamper battery or crushing mill. This method was used at Blue Spur, Waitahuna, and Wetherstones. Subsequently much of the cement was dislodged by blasting, and further disintegrated by hammer, gad, and pick, after which water was led over the face and the material conveyed through sluice boxes by gravitation.

The President referred to Mr Smythe as an optimist and a pioneer, and said that if he got only 10 per cent. of what he expected the country would be the richer for it.

Professor Waters said that Mr Smythe had mentioned 6d per yard as a possible return if the cement were treated. This, in his opinion, was a low value. He would ask Mr Smythe if it were the case that the richest deposits lay on the slide of schist rock. As had been stated previously, treatment of the cement had been carried on by means of stamper batteries, but it must be remembered that in those days the batteries were comparatively light, and that the present-day heavier and greatly-improved type would give better results. He submitted that the successful treatment of these deposits was a problem which should be laid before the Mines Department, and added that a deposit of auriferous cement of such huge dimensions was worthy of thoroughly systematic consideration as to which was the best method of treating the cement and what crushing appliances would be the most successful in disintegrating it. In view of the abundant supply of water power available there could, of course, be no other process than sluicing for the final operations. Mr Smyth was to be congratulated on his paper, which was thoughtful and was not bound up in past history.

Mr W. F. Sligo congratulated Mr Smythe on his paper. He remembered when, some years ago, Mr Donald Reid had established a stamper battery for the disintegration of the cement, which did not prove altogether successful. It was a question whether the material was altogether suitable for treatment by this means, and he would ask Mr Smyth if it were not the case that the gold was more or less free, held together partly by chemical action and partly by its intrinsic weight. If such were the case there should be some method of winning the metal by some other means besides crushing, or without crushing at all. It was a question whether rollers would not be more suitable for the preparatory disintegration.

Mr A. H. Kimbell said that a proposal had been made to the Mines Department some five years ago that the Government should send men to America to ascertain whether it were possible to purchase plant to deal with the cement by mechanical means. Instead of agreeing to that the Department received information from America which pointed to the conclusion that the most satisfactory way would be by sluicing.

Mr J. T. Johnson asked if consideration had been given to a method of lifting the disintegrated material. Some years ago he had investigated tin mining methods in Queensland and the Malay States, and he had also been commissioned to go to Tasmania. By the courtesy of Mr Lindsay Clark there had been placed at his disposal the result of experiments which had been carried out with regard to the different types of elevator, and it was found that where the hydraulic elevator worked to 10 per cent. only of its theoretic efficiency the mechanical elevator worked to 37 per cent. of its theoretic efficiency. If the water power were used only half the water would thus be necessary in the latter case to give three times the efficiency. In addition, he understood that a great proportion of the water would be required for disintegrating the face, so that the saving would be valuable.

Mr Smythe: The gold was undoubtedly richer on the bottom of the layer which lay on the faulted schist rock, but that colours had been found almost from top to bottom of the deposit, which

in places was from 500 to 600 feet in thickness. The streaks which ran through the cement were often rich, and he had seen 11dwt taken from one cubic foot of material.

In reference to Mr Sligo's query, he said that the material was not like quartz, and the gold was not imbedded, but free, and was held together partly chemically and partly by weight.

NEW ZEALAND IRON INDUSTRY.

By J. A. HESKETT.

This paper was read by Mr J. R. Leggo (Nelson) in the absence of the author. The paper, said Mr Leggo, was so technical that he himself had not gone through it. In fact, he did not know what was in it, although he did know the struggles Onakaka had gone through. There had, however, been produced at the works 3000 tons of excellent metal which had been distributed throughout the Dominion, and glowing reports had been received from all the foundries where it had been used. The Northern Steamship Company of New Zealand had a new cylinder constructed from Onakaka iron, and had reported that they had never seen a better casting since the Company was a company. He could assure the delegates that Onakaka iron works were the nucleus of a fine industry. The Government had been kind enough to grant a bonus of 30s per ton, which had been of considerable help, but in time they hoped they would be able to do without this. Meanwhile, he was happy to tell them that even outside the bonus the concern was now showing a small profit. Of course, their furnace capacity of 30 tons per day was a mere bagatelle compared with the huge blast furnaces of Great Britain and India, but those present would realise that the new industry was worth fostering.

The President: The establishing of the Onakaka works was an industry of not merely local interest, but of national importance. If in time of war we were isolated for 18 months we would not have the arms to equip our manhood. Wheat and wool were all very well, but for effective defence we need iron and steel. He was pleased to hear that Onakaka was paying. At present it was an infant just crawling, but when it walked he hoped that the Government would increase its bonus. Britain had become great mainly through its iron and steel industry, and there was no reason why New Zealand should not follow the lead of the Homeland.

In proposing to Mr Heskett a hearty vote of thanks, which was carried by acclamation, Mr J. Horn (M.P. for Wakatipu) said that if war broke out the fact that New Zealand could rely on her own iron resources would be an outstanding factor of inestimable benefit. He could recollect when during the period between 1916 and 1920 it was almost impossible to obtain material for dredge buckets, the price of which rose from £20 to £84 apiece. Such a shortage of iron and steel over a lengthy period would mean that mining would be forced to come to a standstill, and although the weekly output of the Onakaka works was only 200 tons as yet, it was a great thing to know that we had it within our capacity to produce iron and steel from our raw material.

NEW ZEALAND LEGISLATION DEALING WITH PETROLEUM AND NATURAL GAS PRODUCTION.

By A. H. KIMBELL.

Mr Kimbell, in introducing his paper, stated that it was mainly intended to act as a guide to the many people who had hitherto experienced great difficulty in obtaining rights to prospect for oil on Crown-owned lands. Lawyers in different parts had at times been unable to determine what procedure should be followed, and those present would notice that the law on the subject was both comprehensive and complicated. If they turned to page 61 and 62 of his paper they would see several suggestions which might be discussed with a view to having a Bill passed amending the existing legislation and dealing specially with petroleum.

Professor Waters read a letter from Mr A. H. P. Moline, of the Taranaki Oil Company, who stated that in his opinion new legislation was needed in this matter. In addition Professor Waters added that Mr Moline expressed regret at not being present, and stated that the laws covering the prospecting for and development of petroleum, required overhauling. Mr Kimbell's paper had placed before them several valuable suggestions as to how this might be accomplished.

Mr G. L. Tacon said that, although he was not a geologist, he had had a good deal to do with oil in the near East, and he assured the meeting that the position in Greece and Turkey was not unlike that in New Zealand. He urged that, in the event of profitable oil being found, the rights should be vested in British hands, and no other. It was inconceivable that any of the foreign oil companies should have the power to tie us up in a knot. As Mr Kimbell had suggested, a comprehensive oil right should be granted to those who wished to search.

Mr Kimbell, in reply to the previous speakers, said that there was little left for him to say, but he expressed a hope that the Conference would pass a remit embodying the suggestions embodied in his paper.

On the motion of the President a vote of thanks accorded to Mr Kimbell was carried by acclamation.

A SECTION OF THE COAL MEASURES AND ASSOCIATED BEDS IN THE WESTERN PART OF HUNTLY COALFIELD, WAIKATO, AUCKLAND

By JOHN HENDERSON.

Dr J. Henderson stated that it was hardly necessary to make any explanation of his paper, which consisted mainly of an attempt to show the recent borings of the coal beds at Glen Afton and Waikokowai. The sequence of the beds was simple, and beyond presenting the graphic section he had nothing further to say.

The President stated that he was interested in the locality, as he had made the first geological survey of the district in 1885, and knew it well. In those days, however, conditions were vastly different to what they were to-day, as there were no roads and no facilities for transport. He was glad to find that the result of Dr Henderson's investigations agreed with his original survey.

OHAI COALFIELD, SOUTHLAND, N.Z.

By G. S. LANGFORD AND J. J. MOSLEY.

Mr Langford stated that as there had not been much systematic prospecting done on this field, he was not in a position to give a great deal of detail. He trusted that those present would notice that he had drawn attention to the tremendous waste of dross on the field.

Mr J. T. Mosley also referred to the waste of small coal at Ohai, about one-third of which, he said, went over the dump.

The President: Whose fault is that, the fault of the method of working, the fault of the workers, or the fault of the coal?

Mr Mosley: I think it is the fault of all three combined.

Mr P. G. Morgan considered that the joint authors of the paper were to be congratulated. At Ohai a large area was being developed, and the coal was a good household fuel. Unfortunately, as Messrs Langford and Mosley had stated, about 33 per cent. of it became dross. This was nobody's fault in his opinion, as the householders would not use slack, and it was not possible to burn it under boilers, with the result that all this small coal was wasted. The calorific value was just as great as that of large coal, and if it could not be used in its present form it might be used as briquettes or in pulverised form. If a cheap method of briquetting could be found (not by pressure alone—the moisture in the lignite would prevent that being successful), but by means of a cheap binder combined with pressure, the problem of this waste would be solved.

SPONTANEOUS COMBUSTION AND UNDERGROUND FIRES IN COAL
MINES: CAUSES AND METHODS OF DEALING WITH
THE SAME.

By W. AND F. CARSON.

Mr Wm. Carson introduced this paper, and stated that the subject was one of vital importance to coal owners and mine managers throughout New Zealand, as New Zealand coals were all more or less subject to spontaneous combustion. The deductions contained in the paper were the result of many years' experience with underground fires. He and his brother hoped the paper would prove helpful, and would welcome full discussion, as the successful dealing with mine fires made for safety and the economical working of New Zealand coalfields.

The Hon. W. H. McIntyre stated that it was with considerable diffidence that he rose to speak in the company of experts. His only qualifications were that he was a practical miner, with 33 years of coal mining to his credit—10 in the Old Country and 23 in the Dominion. He wished to congratulate the Messrs Carson on their paper, and on their methods of dealing with fires. Everyone must agree with Mr Carson's remark that the subject of mine fires and their treatment was a vital one to everyone concerned with coal mining. One weak point he had noticed in the paper was the fact that the authors did not appear to have given sufficient attention to the prevention of mine fires, and this matter was most important, as fires in a mine were the

managers' greatest nightmare. He maintained that mine fires were due to bad mining methods in the past, and operations had now to be performed to prevent their recurrence, and to attempt their elimination. From practical experience he was convinced that 75 per cent. of the underground fires which occurred to-day were preventable, and one outstanding cause of fires in New Zealand mines was undoubtedly the fact that all numerous cases the pillars were left too small, and the drives driven too wide and too high. He would like to ask Mr Carson the size of the pillars in the Kaitangata mine, and also the thickness of the overburden. He had visited the mine, and was impressed with the smallness of the pillars, which appeared to him to be fretting. He considered that there was all of 500ft of overburden, and this being the case the size of the pillars was quite inadequate. His experience in the Old Country was that the pillars were twice as long and twice as broad. Further, he would have no drive more than 12ft wide or 12ft high, and he submitted that the Conference should give the Government a lead in establishing legislation which would force all pillars and drives to be of a standard size; this, incidentally, would assist in the prevention of fires.

He had seen a fire in the Old Country effectually sealed off with only two stoppings. In the mine where he worked there had been a number of fires, and no less than 43 stoppings 16ft to 18ft high and 18ft to 20ft wide had been built at enormous cost. A strong comparison could be drawn between this and the economy of only two or three openings. In conclusion, Mr McIntyre said that he hoped the paper would provoke discussion, and that it would be impressed on mine managers that it was necessary to evolve some scheme for the prevention of fires. In any mine, fires not only meant a great loss of coal, but also a shortage of its life.

Mr A. G. Macdonald (Malay States) said that there was one coal mine only in Malay, and the coal was particularly subject to spontaneous combustion, so much so that it could not be bunkered. The company had introduced another method, that of filling with sand, which had proved very successful. The drives in the mine were now only six feet wide, any extra width being also sand-filled.

Mr A. S. Gillanders agreed with Mr McIntyre in his remarks regarding the size of pillars. Kaitangata coal was very liable to spontaneous combustion, and he had seen heaps of it burning on the side of the roadway. One difficulty he found was when a pillar was taken down the heaps of small coal under the falls invariably fired, and it was found necessary to shut off that area. He had found that the adoption of larger pillars and the installation of panels had gone a long way towards the minimising of the frequency of fires. He also agreed with Mr McIntyre's statement that fires could be prevented, and he had found that one sound rule was to keep the mine as free of small coal as possible. Kaitangata was to be congratulated in that it had had no fires in the past few years.

Mr Armstrong endorsed the remarks of the previous speakers, and said that there was only one part of Scotland where coal seams were liable to spontaneous combustion, and that was east of Fife. The seams were 21ft thick, and were worked on a modification of the pillar and stall and long wall methods. The areas were cut up in panels and the seams worked on the long

wall inside the panels in three lifts of seven feet each—two advancing and one retreating. In case of fire the panel was sealed off. He agreed with Mr McIntyre's advocacy of the panel system, but whilst he admitted that it would help control fires, he did not consider that it would prevent them. In regard to rescue apparatus, he held the opinion that the smoke helmet and canaries were the safest, with the pulmator in reserve for revival purposes. Referring to the paragraph in Messrs Carson's paper dealing with explosives, he held that it was not CO which caused explosions, as while .1 per cent. of CO was fatal to human beings, it would not be sufficient to cause an explosion. More probably the explosions were due to either CH_4 or H_2S .

Mr E. S. Wight said it was easy to criticise after the event, and he did not agree with Mr McIntyre's statements that all fires were caused through bad mining methods. He had once been invited to look at a fire in a solid pillar. This fire had first been seen in the roadway, and was thought to be due to neglect. He was not a scientist, but a mine manager, and through having read a bit had come to the conclusion that fusain was responsible for many fires in pillars. This substance was remarkably sensitive to heat, and would ignite with a match or if brought into contact with the ash of a cigarette. He had given a good deal of attention to this matter, and in his opinion more fires were attributable to fusain than to neglect on the part of the management. He would ask Mr Carson if his panels were sealed off before pillaring.

Mr J. Watson instanced a case where he had found a heated pillar where there was no slack to catch, and on splitting the pillar he had got pieces of coke showing that it had been heating for months. The method of treating fires mentioned in Mr Carson's paper was adopted in most mines worked on the panel system. Sections could easily be sealed off, but Mr Carson had found out from experience that when a serious fire occurred in a mine it was next to impossible to seal the return. Continuing, Mr Watson said that he knew that large quantities of coal had been lost chiefly because the mines were not worked on the panel system. In the past mining had not been carried on as it should be, and managers under pressure from the directors were prone to neglect precautions in an effort to secure a maximum output.

Mr P. G. Morgan said that many years ago—in 1890—he used to know a little about the subject under discussion, as he had been attached to coal mining for many years, and he wished that the information contained in Messrs Carson's paper had been circulated 40 years ago. During the course of the discussion he had understood Mr McIntyre to say that all mine fires were caused by bad mining methods. Some of them undoubtedly were, but in numerous cases the quality of the coal was a contributory feature. Some managers had said they had seen fires in solid pillars, and he could bear this out, as he himself had seen a fire which started in a pillar. He had noticed that the paper did not deal with certain aspects in the detection of CO, but that was such a wide subject to cover that it really merited another paper of its own. In conclusion, Mr Morgan said that he was right in saying that this paper alone had justified the holding of the Conference.

Mr L. O. Beal said that in his 40 years' experience of mining he had to deal with many fires in mines, and he was glad to see Messrs Carson's paper brought forward, as it concerned a very vital subject. He had been called in to deal with many mine fires in his experience, and he had found that in many cases they were due to the fact that the pillars were left too small in the first workings, and where there was considerable dip a great pressure was necessarily imposed on the pillars. This resulted in fractures and a collection of small coal alongside the cracks, so that when the pillar felt the strain, friction was set up in the joints, creating heat, which ignited the slack. Due to strong competition, and attempts to cheapen the cost of production in the early stages of working, it was quite the exception to find pillars large enough. Referring to the control of fires, Mr Beal said that brick stoppings were not altogether satisfactory, as in a mine where a great pressure existed these stoppings were liable to open at the joints and thus allow ingress of air. Ventilation, too, played a prominent part in the prevention and control of fires, stated the speaker, and he maintained that if the air were carried as straight as possible and all loops in the ventilating course eliminated it would assist materially in cutting out fires. At Kaitangata, owing to the heavy overburden, there was great pressure, which made the risk of spontaneous combustion greater. The cleaner the mine was of dross the less risk was there of fire. Further, there should be a plentiful supply of water laid on. In mines where the pillars were small it was impossible to keep the stoppings tight, and without water there was always a chance of fire getting complete mastery. He also advised the use of a large number of stoppings, and stated that it was unwise to open too large a district at one time. It was always a safe plan to put in a large number of stoppings whether they were wanted or not, as one could never tell when they would be wanted.

Mr Strongman laid a good deal of the blame for mine fires at the door of the company directors. The managers, he said, were not the only ones responsible. The companies often expected the managers to work wonders. Prospectuses were issued in glowing terms and the manager had to get the maximum output at any cost. Pillars were left too small, and in many cases split, with the result that fire broke out. He had interviewed many managers, and all had expressed their utmost willingness to help, but they were powerless against the orders of the directorate, and thus the biggest part of the blame should be put on the speculators. It was all very well laying out a mine on text book specifications, but before a manager could do this, he must have the money. The question of laying out a mine should be investigated by experts before handing over to the manager, and the size of the pillars, methods of working, and ventilation properly gone into.

Mr T. Thomson considered that brick and concrete stoppings were of little use. He thought that a double stopping, packed with sand, was safer and better. The panelling system was now getting a big vogue, and while there was no doubt it was a great saving in regard to mine effectiveness, it was doubtful whether it resulted in an increased output of coal. In reference to Mr McIntyre's statement regarding bad mining methods, he would state that he had known of no fires at Westport due to this cause, and that such fires as had occurred were the

fault of some foreign substance in the coal. He had found that by systematic panelling, fire could effectually be blocked out, thus leaving whole areas intact. He wished to congratulate the Messrs Carson on their paper, which, although it was not exactly perfect, was certainly on the right lines.

Mr G. Duggan said that in his opinion the size of the pillars was a big factor in regard to the causing of mine fires. It was certainly easy to criticise, but not so easy to find a way out, but he thought that the size of the pillars could be increased with advantage.

The dross in the mines, too, was a matter that should be attended to, and if he had his way, he would not have a harp or a fork in a mine—they should be relegated to the museum. At present, when dross was found in mines, it was left for the time being, and the miner's tale was that they were short of boxes. Dross left like this, he maintained, was a potential source of danger. Although the panel system was not ideal, it was better than acres of open workings with the air coursing through all.

Mr Armstrong said that he considered the great advantage of the panel system was that it (1) divided the mine into well-defined districts; (2) enforced method and organisation; (3) provided quick isolation in case of fire; (4) lent to efficient and systematic ventilation. Referring to stoppings, he said that another system that had proved efficacious was the hydraulic method of filling and packing stoppings.

Mr J. C. Brown, referring to the discussion on the size of pillars, admitted that this was an important factor in the causing of fires; but he did not consider it the sole cause. There was, for instance, also the question of spontaneous combustion, which was well known throughout the mining world. He ventured to say that no fire that had occurred in any of the Westport Coal Company's mines had been caused by undersized pillars, but he was prepared to admit that careless extraction of pillars might sometimes be responsible. At the Denniston Colliery, they were now stopping out before extracting the pillars, and were hopeful that this would minimise the risk. In his opinion the panel system would modify, but not eliminate fires, always providing, of course, that the panel were not too large, as where a panel had a shallow cover, and a fall break to the surface, the fire would burn inside the panel. He had dug some fires out and sealed some off, but he was not prepared to say what material made the best stopping. He knew, however, that the best stopping was the one which would keep the air out. He had known a stopping made 3ft thick, of brick, and backed with 3ft 6in of sand, which yet drew air. He would admit that a rigid stopping was liable to crack, but the main thing was to do the best possible with the material at hand. In connection with fires in solid pillars, Mr Brown instanced a case where he had found heat in a solid pillar and in digging into it, had found a fire no bigger than a five-shilling piece, this going to show that foreign matter played an important part in the causing of mine fires, and that the size of the pillar was not the whole factor.

Mr W. Donovan pointed out that there was some similarity between mine and bunker fires. As a rule, fires occurred in a bunker just where fine coal was thrown in, and where fine

coal was most abundant. Some coal would ignite easily in the lump with an ordinary match, but any coal, if ground fine enough would ignite by this means.

Mr Armstrong stated that a factor in the oxidation of coal was the air impinging on the coal through small crevices in an air stopping between the intake and the return. This, in conjunction with the water vapour in the ventilation, caused rapid oxidation and tended to spontaneous combustion.

Mr W. M. Barclay said that in four years he had known four fires in solid pillars in each case, between the intake and return, and in each case due to fusain in the pillars. This was more prevalent in small pillars which had been cracked, and it appeared that through these small cracks and avenues the fusain absorbed oxygen, and thus caused self-heating. It would be interesting to know the temperature of ignition of the various brown coals existent in New Zealand.

Mr Langford asked what the effect would be if inert gases were introduced into the mine to extinguish fires. He had tried forcing air into the mines through the ventilating course, and this method had been of great assistance in keeping the mine clear of gases.

Mr J. C. Bayne complimented the Messrs Carson on their paper, and was sure that all those present had received a great deal of benefit from their account of the work done at Kaitangata. He was convinced, and it was unreservedly agreed, that the cause of mine fires was originally due to oxidation of coal. It must be obvious that crushed coal was more prone to ignite than large. His experience had been that a great percentage of fires had been due to the small coal and heat resultant on the crushing of pillars. Heating in the centre of a pillar was, in his opinion, easily dealt with, and as a rule fires round the edge of the workings were not dangerous. He did not agree with Mr McIntyre in saying that bad mining methods were the cause of all mine fires; but he was firmly convinced that fully 75 per cent. of fires were due to bad mining methods. The best means of prevention seemed to be the adoption of larger pillars than were usually found in mines, and the introduction of the panel system of working. He had heard the panel system criticised on the ground that it made ventilation difficult, but his experience had been that it was easier to ventilate with panels than without. Again, the statement had been made that in the case of a fire in a panel which had been sealed off, the whole panel had been destroyed. This, again, had not been his experience. Further, there could be no question that the cost of dealing with a fire in a mine which worked on the panel system was much less than in one where there were no panels. Mr Beal had suggested putting in more stoppings than were necessary. This system had been tried out in the Waikato District with the result that there had been no fires since. Mr Cheeseman would also show that the panel system had given excellent results. It had also been stated that when a panel fired all the coal was lost, but his experience had been that unless the fire were very serious, the bulk of the coal could be taken from the next panel.

The case for better methods was strong, and he doubted whether 40 per cent. of the coal available was got from some mines which had been abandoned in most cases through fire.

Mr W. Leitch said that as a mine manager he had had trouble with mine fires, and had dealt with them fairly often, by the same methods as were originally used at Blackball. He found that when he took out pillars he could not get the panels in quickly enough, and he had found the panel system gave no trouble. The panels should not be too large, but should be kept small—this allowed a greater percentage of coal to be extracted, the fires could be dealt with more easily, in addition to which the coal could be got out better. In constructing stoppings, it should be remembered that both stoppings should be built at once and sealed off at the same time, as if the intake were sealed off first there was a certain amount of risk. Regarding the material for construction, he had tried them all, but he had found that the best was fireclay. Stoppings of this material had been built 15ft thick, and it was found that when the weight came on them they used to tighten, and were rarely known to leak. Out of 700 fireclay stoppings he had put in, on two occasions only had he known the fire burn through one of them. He agreed that the panel system was better for ventilation, and thought that the statement that the air velocity became too low when numerous panels were used was wrong. This difficulty could be eliminated by closing up a panel as soon as it was finished. He would ask Mr Carson if, after sealing up, he had had any difficulty in opening up again, and if so, how long was it before he opened up.

Mr A. F. O'Donnell said that the coal in his mine was not subject to spontaneous combustion. He had tried pillars one and a-half chains square to get better working results, but with disastrous results. He had then tried pillars two chains square, and the results were better, but the ventilation was difficult; he therefore went back to the original design.

Professor Waters congratulated the authors on their paper; and the amount of discussion it had provoked must be highly gratifying to them. In reference to Mr Wight's remarks regarding the firing of coal, it was a thing that was not easily understandable. In an ordinary analysis of coal ash, sulphur and carbon were found. These did not occur in coal, they were got by analysis. Nobody actually understood the reason of spontaneous combustion, and it was equally difficult to understand why different coals fired more easily than others. If all these things were understood, then it might be possible to prevent fires in coal mines. He remembered the case of a fire at Taratu, when the fire had spread all over a stopping. The heat was intense, and water could not be obtained to reduce the fire or the temperature. He had suggested pouring CO₂ over the stopping and accordingly 250 cubic feet of CO₂ were used for this purpose, and reduced both the fire and the temperature. He had designed a small CO₂ plant, which could be easily taken about a mine, but it had not got past the design as the cost of production would have prohibited its use, and was more expensive than buying a large cylinder of CO₂. An electrical pyrometer would be useful in assisting in determining what degree of heat existed on the burning side of

a stopping. The wires could be led through the stopping, and the indicator would record the temperature and give the workers some idea of what was going on inside.

Mr J. Hadcroft said that the three main suggestions as to the cause of mine fires seemed to be slack in the mines, small pillars, and heating inside the pillars. In reference to the last he would say that if the pillar were solid, oxygen could not get to the heart of it, and this being so, he could not see how it were possible for the heart of the pillar to fire. He would ask if any case were known where a pillar had been found burnt in the first working. He would suggest that for a pillar to fire, there must first be some fracture in it. He did not consider that brick stoppings were a success. At Taratu they had tried concrete, which had been quite successful.

Mr Armstrong said that although the matter had been well threshed out, one important detail had been missed, and that was the means of application of a supply of compressed air. The effect of heat on oil in the cylinders of a compressor would generate CO₂ to the detriment of the miners. He had seen its bad effect on several occasions.

Mr W. Carson said that he would try to answer the questions asked, and sum up the opinions offered on the different methods of preventing mine fires, and the matter contained in the title of the paper. Mr McIntyre had raised the point that pillars were too small, but unfortunately, the Kaitangata mine, as well as many others, had been inherited many years ago with the small pillars already in existence. In reply to Mr McIntyre's question, he would say that the size of the pillars left in his mine was either chain by chain, or chain by 40ft.

Regarding Mr Armstrong's remarks in reference to CO, he could not be sure whether the gas mentioned in his paper was CO or CH₄, as he had not been able to get near enough to take a sample for analysis; but he had come to the conclusion that there was a large proportion of CO on account of its effect on the men dealing with it who were overcome.

In reference to Mr Wight's query as to panels being sealed off before pillaring, they had two methods—viz., driving to the boundaries, and taking out on the retreat (if the money were in hand this method was all right), but they generally opened out the sections and then pillared. When a working had been standing idle, an accumulation of gas took place, and it was advisable to seal it off till ready to be used again.

Mr Donovan had inquired what coal fired most readily, and he would state that, in his opinion, soft coal did. In all workings where the pillars had crushed the fire had been found creeping in the crevices where the coal had been ground to powder. This crushed coal was also often found warm, although there had been no pressure acting on it, showing that it was more liable to spontaneous combustion than lumpy coal.

Regarding Mr Leitch's question in reference to the closing and reopening of panels, Mr Carson said that when a fire took place in a working it was necessary to seal it off, as there were pillars inside that they did not want to lose. The stoppings would tighten, and after three months they would be examined, when, if it were found that they were cool,

they would be reopened in order to allow access to the seat of the fire as soon as possible. When it was reached, and it were found that the fire was active, it was sometimes possible to quench it with water but the main point was to reach the seat of the fire as soon as possible.

Replying generally to the question of the size of pillars, Mr Carson continued that the size should be sufficient to support of strata to prevent creep and to provide for the most efficient working of the mine but it depends largely on local conditions. Some managers had good roofs, but it was always essential to have pillars strong enough to prevent creep and disturbance and it was also very important to have the main roadways of sufficient size. As to stoppings neither brick nor concrete was to be despised, he had used both but conditions at Kutingati were different to what they were anywhere else in New Zealand. He had found that first stoppings made of wood packed with sand or ashes were very satisfactory. Ashes made the best packing and in most cases where a stopping packed with ashes had been put in the floor and the roof came together and made the stopping tighter. Brick stood well but it was necessary in constructing a brick stop to build one wall right from floor to roof—if necessary cutting into the ribs to strengthen it another outside wall should then be built and between the two tamped with ashes or sand. It should be noted however that a space should be left between the second wall and the roof to allow entry for a man to retamp the filling.

In regard to methods of working mines he thought they would find that by dividing the mine into sections and leaving as few opportunities as possible for fire to pass through would be the most satisfactory. It would also be found that by sealing off each section as it was worked out the ventilation from it would not interfere with that of other sections nor could fires pass through from one section to the other.

Generally summed up the principal factors in the successful working of a mine were (1) pillars of sufficient size (2) the clearing away of all dross (3) the sealing off of all burning areas (4) good ventilation. The manager who attended to these features would not only be working in the best interest of the owners but also making for the economical working of the mine. In conclusion he thanked those present for the attention they had given his paper and hoped that it would be the means of helping not only mine managers but mining generally.

Mr F. Carson also spoke briefly and said that between himself and his brother they had endeavoured to give the conference the benefit of their experience. They had not come before the conference as fire bugs—they liked to see a fire inside a mine and to keep it there. The manager in a mine which was liable to spontaneous combustion needed to realise that all the responsibility lay on him, and that it rested with him to see that fires were dealt with as promptly and effectually as possible.

Mr W. A. Flavell, in moving a hearty vote of thanks to the Messrs Carson said that the paper had been a valuable contribution to the subject, and that the discussion had been intensely interesting. Summing up, the trend of the matter

original, but which had been in use in Britain for many years, for four years in the State mines of Victoria, and 18 months on the West Coast, and it had proved to be a huge success. Mr Leitch drew attention to diagram 3 in his paper and stated that the heating for the oil for the wire rope should be done by steam.

Mr Armstrong asked if grease were a better lubricant than oil for bearings running around 100 revolutions per minute, both from the point of view of efficiency and economy.

Mr Leitch, in reply, said that in conditions where there was a great deal of dust in the vicinity of the bearings grease was the better lubricant as it formed a fillet round the end of the bearing and thus prevented the ingress of dust. Without dust oil was always a better lubricant than grease in every way.

INVESTIGATIONS ON THE BRIQUETTING OF NEW ZEALAND COALS

By W. H. A. PENSELER

Mr Penseler said that it would be noticed that he had first dealt with the technology of briquetting, and second with the qualities of the various coals. Apart from the pressure method he had for some time been investigating the possibilities of the fusion method and it was found that poorly coking coals gave quite good briquettes as regards both toughness and hardness though with strongly coking coals such as Rewaihi and some Westport varieties the resultant briquettes were having a perfect hard, smooth surface were extremely brittle. For poorly coking coals such as James, Invercargill and others a comparatively high volatile content and high volatile content from these coals required therefore, to be kept under pressure until cooled to prevent the escaping gas from disrupting the briquette. In the case of strongly coking coals too it was necessary to keep the briquettes under pressure until cooled below the fusing or softening point of the coal. In order to confer the property of toughness on the briquette made from strongly coking coals various experiments were tried out. It was found that the addition of coke ground to pass a 30 mesh sieve, in amounts varying from 10 per cent to 40 per cent produced an excellent hard tough briquette the effect of the coke being to take up the excess binding material in the fused coal and form a hard or tough skeleton on which the material of the briquette was built. As a substitute for coke a non-coking coal such as the Winkato type was tried but gave a friable briquette. Some of this coal was then heated to about 450 degrees C in a closed retort and the resultant semi-coke used. This gave quite good results, though not quite so good as when using the previous high temperature coke. The pressure used varied from half a ton to one ton per square inch, but the lower pressure gave just as good results as the higher. A lower pressure than half a ton would probably be quite satisfactory. He invited suggestions and discussion.

Mr P. G. Morgan said that this and the paper on 'Mine Lubrication' were both by recent graduates of the Otago School of Mines, which was to be congratulated on having

turned out two such pupils. The subject of coal briquetting was a very important one, and it was one which he had had in mind for some time. Although experiments had been carried out, they much not expect great results offhand. New Zealand coals differed, and different methods had to be used. Some years ago briquette-making works had been established by the New Zealand Government at the Seddonville mine. Good briquettes were manufactured, but the works did not pay, and it had occurred to him that some good could have been done by using them for research work. He thought it a pity that the works had closed down without trying other New Zealand coals. He would like to ask Mr Penseler what could be done with starch as a binder.

Mr J. C. Bradley complimented Mr Penseler on his paper, and said that for two-thirds of his life, more or less, he had been conversant with methods (some or them more or less crude) of briquetting waste coals. He had first seen briquetting carried out at Swansea in the early seventies, where there was a high-class but soft coal which pulverised easily, and the only way the public could use it was by mixing it with clay and thus forming an effective and cheap briquette. Bessemer had also in the early seventies, invented an elaborate machine in which the coal was heated to about 300 degrees C, from which quite a good briquette was turned out. At a briquetting works at Cardiff he had seen silicate of soda used as a binder. He knew that by this last method foreign matter was introduced into the coal, and not increasing its calorific value, but surely we could afford to do this when we considered that the Dominion was importing Australian coal which contained fully 15 per cent of foreign matter. He thought it important that such vast quantities of small coal as were lying idle should not be allowed to go to waste.

Mr W. Donovan, as one who had experimented in the Government Laboratory in regard to briquetting, said that in reference to Mr Morgan's remarks touching time being taken in investigation a good deal of investigation was now going on at the laboratory, and they were fortunate in having the services of Mr Penseler. First they had to try to get away from the binder, and they had found that with lignite it was impossible to briquette without a binder. He had suggested that a mixture of bituminous coal and lignite might be successful. Numerous binders had been tried, but as far as he knew nothing had been so successful as the universally-used pitch or bitumen. In reference to briquetting plants, a firm in the Old Country had quoted several machines from one with a 25-ton capacity in eight hours and costing £1425, to one with a capacity of 100 tons, costing roughly £3000. He added his congratulations to Mr Penseler not only on his valuable paper but on the great value it had been as a possible solution of the problem of utilising our waste coal.

Colonel Holgate also congratulated Mr Penseler, and said that the waste coal in New Zealand was becoming a serious problem, considering that geologists had stated that the Dominion was not over-supplied with coal. Our soft coal was too valuable to be wasted, and it behoved them to energetically pursue the researches in this matter. He would like to ask the author of the paper if he had received any data

on the subject from France, Belgium, Great Britain, or the United States of America. Although he knew that briquettes were being manufactured in the first three countries fairly extensively, he did not think that such was the case in the United States of America. He wondered whether the department thought it worth while to use pulverised coal as was being done in Canada, where the trains were being run largely on pulverised coal. He asked this question as the Dominion would, as time went on, have more and more slack coal on hand. In the meantime he would urge that the department energetically pursue research in this matter, not only in the interests of mining, but in the interests of the country.

The Hon. W. H. McIntyre disagreed with Colonel Holgate saying that the Government should pursue research in the matter of briquetting, and thought that this should come within the scope of the coal owners. The Government had done well to go so far, and it was a pity for so much research to be pigeon-holed. Steps should be taken to ascertain the cost of bringing a plant from Europe to New Zealand, and the coal companies should contribute towards sending a smart man to investigate methods in vogue on the Continent and Great Britain. He would suggest that research be gone into on a larger scale, and that the coal companies should contribute by a small royalty on each ton of coal produced, and a £1 for £1 subsidy of this amount would bring in an annual revenue for research work. He would further suggest that the conference that day appoint a committee to go into the matter and report to the conference at a later date. Pulverised coal might very well be used in New Zealand, and the coal companies should contribute towards any scheme for making their product more suitable for the market.

Mr J. C. Bayne said that in view of the very great difficulty that many mines experienced in getting rid of their slack, the results of Mr Penseler's experiments were of great interest, and held out hope that they might yet get a market for their slack. Experiments had gone to show which were the most suitable coals for briquetting, and the results demanded further investigation. Mr McIntyre had opened up the question as to how far they should go with these experiments, and he maintained that they should go as far as possible, and agreed with Mr McIntyre that the coal companies should contribute towards the cost of the necessary research.

Mr T. O. Bishop mentioned one or two points that had not been brought up. For one thing, slack coal in the Waikato district was sold at cheap rates, and was meeting with increasing competition from hydro-electricity. If slack were made into dear fuel, such as briquettes, it could not hope to compete with electricity. The Canadian Mines Department had been extensively engaged in trying briquettes made from a mixture of high grade coals from the East and West, and the low grade coals from the centre of the Dominion, but these had not been successful. The department had now abandoned research on briquettes and was concentrating on pulverised fuel, which was able to compete with hydro-electricity in the point of cheapness. Briquette research should by all means be pursued, but they should also carry on with the investigation of pulverised coal—one was dear and the other cheap. Regarding

Mr McIntyre's suggestion that the coal companies should contribute, he could not see why the Government should not do it, as the Government in every other country was doing. This Government lagged behind every other country in research, the problem was a national one, and the results would benefit New Zealand. At the most, the coal companies' lives were short, and he would not urge that the onus be laid on them for the benefit of posterity.

Mr G. Townsend asked if Mr Penseler had formed any idea of the loss entailed in heating the coal for the preparation of briquettes.

Mr E. S. Wight said that he had watched the slack question carefully and that, due largely to changed conditions, there was a greater percentage to-day than there was 25 years ago. A year or so ago, the demand for slack reached its zenith, but since then it had fallen back, and shortly there would be no sale for it at all. Regarding the coal companies contributing towards research, it had to be remembered that most of the collieries were on Government leases, and if the slack were not utilised, it stood to reason that the Government were losing royalties, it therefore behoved the Government to go as far in the matter as possible. Would it be asking too much of the Government to experiment along the lines of finding whether oil could not be procured from coal?

Mr Bayne contradicted Mr Bishop's statement that the Government lagged behind in research work, but agreed with Mr Wight that as royalty earners they should assist in finding a means of using slack coal.

Mr Armstrong said that in other countries, experience had gone to show that the manufacture of briquettes was an exceedingly doubtful experiment. In Australia one plant had been erected at a cost of £160,000, and it was doubtful whether it would pay interest on the money. He suggested that the Government should be very careful in buying expensive plant without careful preliminary investigation.

Mr Penseler, in replying, said, in reference to Mr Morgan's query, that starch had been tried as a binder, but that as it had to be imported, and before using, had to be liquified and dried, and finally the briquettes had to be baked and dried to make them waterproof, the cost was thus prohibitive.

Regarding Mr Bradley's inquiry as to the use of soda silicate as a binder, Mr Penseler said that experiments had proved that although it held together, a large quantity was required, and it resulted in increased ash, besides which it was very expensive.

In reply to Colonel Holgate, Mr Penseler stated that he had received literature on the subject of briquetting from every country in the world interested in it, before taking up the work. In reference to the United States of America, it was true that that country had not yet taken up briquetting, but with its huge deposits of coal, this had not been found necessary. This country had, however, made extensive investigations into the matter.

Regarding Mr Townsend's inquiry, the author said that the percentage of loss of volatile matter could only be told in the laboratory, but it was somewhere about 5 or 10 per cent. As the calorific value increased, however, this balanced any loss.

In answer to Mr Wight, Mr Penseler said that with coal slack of the Waikato type a certain amount of bituminous coal had to be added. Regarding the extraction of oil from coal, a good deal had been done by low temperature carbonisation, but very little oil was extracted—in any case coal oil could never take the place of well oil.

Mr Penseler said that he knew the plant mentioned by Mr Armstrong—the Morwell plant, in Victoria, which was dealing with lignite. When erected tests showed 40 to 60 per cent. of moisture in the coal, which militated against the successful making of briquettes—making briquettes from lignite was a vastly different proposition to making them from bituminous coal. In Germany, there were marketed yearly 30,000,000 tons of briquettes, which were supplied to all the large towns and were used largely for household and railway purposes.

Regarding the erection of plant, the author said that the great thing was to successfully blend the many coals in New Zealand so that a standardised briquette could be produced. The calorific value, ash content, and sulphur content, could then be properly determined.

On the motion of Mr Flavell, a hearty vote of thanks was accorded to Mr Penseler.

MINING EDUCATION ON THE WEST COAST, SOUTH ISLAND, NEW ZEALAND

By J. F. MCPADDEN

Mr McPadden stressed the necessity of the Mines Department taking over sole control of all Schools of Mines. At present the local committees contributed 10 per cent. of the working expenses and the department 90 per cent., with the result that their finances were anything but stable. It should not be a difficult matter to put the whole thing on a better basis.

In reference to scholarships, Mr McPadden said that he considered it unfair that candidates should, on attending the Otago School of Mines, be compelled to again study subjects in which they had already passed. In the matter of oral examinations, Mr McPadden went on to point out that candidates for mine manager's certificates, if successful in the written examination, were required to travel to Wellington at their own expense for oral examination.

The Chairman said that this matter appeared to be covered by remit 3b.

Mr McPadden further moved: "That the Department of Mines be asked to take over the control of all schools of mines throughout the Dominion. The motion lapsed through the want of a seconder.

Mr McPadden further moved: "That the winners of scholarships attending the Otago School of Mines be not compelled to take a course of lectures in subjects in which they had already proved themselves competent," was seconded by Mr McIntyre and carried.

The President (Professor Park) now took the chair.

THE CLAY RESOURCES OF NEW ZEALAND.

By W. DONOVAN.

Mr Donovan said that he was carrying out the behest of those who said that New Zealand's mineral wealth did not lie entirely in gold. His paper did not cover the whole of the clay deposits of the Dominion, and such theories as were contained in the paper were built up mainly from laboratory tests, analysis, and comparisons in firing tests. In classifying the various clays brought to him from time to time for analysis, he had found that New Zealand had large deposits of clay of various kinds, but until such time as a thorough investigation could be carried out nothing much could be done. After proper survey and investigations of the deposits, there was, perhaps, the possibility of an export trade being built up.

Mr J. G. Bradley said that New Zealand did not appear to realise the importance of having material at hand for the construction of retorts. In Auckland, Wellington, and Christchurch were works which were looking out for the best clay procurable, and he was sure that if samples of New Zealand clay were sent along to these works, they would be pleased to test it, and if it were suitable, they would receive their reward. The subject of clay had engaged the attention of experts in Great Britain, and specifications had been drawn up stating the various types of tiles and bricks required to stand certain temperatures. He thanked Mr Donovan for his paper and for the report he had turned out, which he was sure could be depended on.

Mr P. G. Morgan said that this paper was only the forerunner of other papers on the subject. In her clay deposits New Zealand had an asset of great value regarding which, unfortunately, very little had been done. The first thing necessary was to collect a large amount of information such as was set out in Mr Donovan's paper.

Mr Donovan drew attention to a misprint on page 265 of his report, stating that "National History of Clay" should read "Natural History of Clay."



DISCUSSION OF REMITS.

ALLEN HALL, FEBRUARY 4.

PROFESSOR PARK (PRESIDENT) IN THE CHAIR.

REMITTS FOR METALLURGICAL SECTION.

Remit B (1) "That the Mining Act, 1908, and its amendments should be consolidated."

The President: I do not think we need to consider this remit because the Minister has assured us that a consolidating Bill will be put before Parliament at an early date. I think we should thank the Minister for his foresight in attending to this matter. I move a very hearty vote of thanks to the Minister for his action.

The motion was carried unanimously.

Remit B (2). "That the department should institute an office of mining warden for the whole of New Zealand. The holder of this office should have technical knowledge and experience of the conditions of metalliferous mining throughout New Zealand. The mining warden should take over the work done by the present district wardens."

Professor Waters.—I am responsible for this remit, and I would like to explain why I put it in. This has been a pet theory of mine for the last 20 years, but I have never previously had an opportunity of putting it before the public. In the first place I consider that in the Mines Department there should be an opportunity for a district inspector to rise to the position of Inspecting Engineer and then Under-secretary, and the Under-secretary could then rise to be Mining Warden for New Zealand. A mining warden, such as I have proposed, with the whole knowledge of the Department behind him, would, I consider, be of very great benefit to the industry. He would know not only the legal side, but he would understand better whether those applying for concessions, claims, and easements were trying to bluff him. In the Mining Act there are certain clauses stating that a Warden has power to alter, it may be, the decision of an inspector. I do not think that an ordinary magistrate looking at the matter from a purely legal point of view, should have that right in regard to technical matters. I move the adoption of the remit so that we may have some discussion on the matter.

Mr A. G. Macdonald, at the invitation of the Chairman, said that the Mines Department in the Malay States is a purely technical department. It consists of a senior warden, who rises from an inspectorship to the wardenship. He is the head of the whole Federation, which consists of four States. Each State has a warden as the technical man in charge, and under him are the inspectors, who are supervisors of districts. Theoretically every man joining the department has a chance of becoming Senior Warden. From what I understand of Professor Waters's scheme it seems to be on the lines adopted in the Malay States. The scheme works very well there. The wardens hold what are called wardens' courts, which deal principally with prosecutions in

connection with the Mining Act. A technical man sitting on the bench knows better than a magistrate would when a man was bluffing, and we have found that the miners get a much better hearing before a warden's court than before a magistrate. Lawyers are not allowed to appear in a warden's court. Mining applications are made to the Lands Department, and are then referred to the Mines Department for a technical report, but the actual leases are granted by the Lands Department. The whole staff is a technical one and there is no administrative head. The senior warden is responsible direct to the Government for the conduct of the department. I think the staff numbers about 22 including one senior warden, four wardens, and a number of inspectors. I think that about four men are on leave at one time.

Mr T. W. Rhodes, M.P.—Speaking as one who has had 20 years' experience of warden's courts, I appreciate the desire to bring about a better state of affairs than exists at present, but I am convinced that if we adopt the remit and it is brought into operation we shall be making a retrograde move. Our present system works very well. I have known many wardens. If we one Mr I. J. Burgess and I ask you whether a man would succeed in bluffing a man of his calibre. We have men who are not ordinary magistrates and who generally speaking have been selected because they have an intimate knowledge of mining conditions and who are most painstaking in the discharge of their duties.

Mr W. F. Sligo.—I disagree with Mr Rhodes. We had good wardens in the days gone by and probably there are still capable wardens but there are many who are not capable. I think Professor Waters's suggestion is a good one and I am going to support it.

Mr Burgess.—I am speaking with 20 years' experience of warden's courts in the North Island. It seems to me that the appointment of one warden for the whole of New Zealand would cause a tremendous lot of delay in getting applications through. It would be almost impossible for one warden to deal with both islands. Even if there were one warden for the North Island and one for the South Island there would be great delays. In the second place miners have the utmost faith in the warden for the district. To say that because a man is a magistrate he is not as good a warden is surely placing the magistrate in a wrong position. It seems to me that the idea of having a rough and ready technical man as warden would not be a good thing on a new goldfield. All sorts of out-cres arise in which great injustice might be done if a man did not have a legal training. It seems to me to be a retrograde step to suggest that a technical man would make an ideal warden without any legal knowledge. All the miners I have come in contact with have the utmost faith in the wardens and it is a very rare thing to hear of an appeal.

Mr P. G. Morgan.—What Professor Waters proposes seems to be a revolutionary kind of a change. As I understand the remit the warden would be travelling continuously from one end of New Zealand to the other, and would be really worked to death. I ask Professor Waters to state whether it is his intention that the chief warden should travel continually from place to place. If he does not, how are delays to be avoided?

Professor Waters.—I know many wardens, and I have nothing to say against them, but still believe the appointment of a mining warden would be of advantage to the industry, looking at it from the technical side. I consider that the warden would have to travel about. He would have a knowledge of the whole mining industry of the Dominion and to say that there would be delays, I think, a very small matter, because down here most of the warden's courts sit only once in three months and everybody knows that when he gets an application in his ground is secure until the warden sits so that there is not the terrible need for haste which some speakers have mentioned. I consider that one warden could carry out the work and I believe this would be a step for the benefit of the mining industry.

The President: I think it would do no harm to send the report forward. No change could take place without an amendment of the Act and the Act cannot be amended without the matter coming before Parliament. I think the report should be sent forward so that the question can be ventilated. The report involves a drastic change of policy.

After a vote had been taken the President declared the motion carried.

Remit B (3) That the recent regulations in regard to alluvial mine managers' certificates are unfair to holders of first class metal mine managers' certificates and are not in the best interests of alluvial mining.

Professor Waters.—Last year regulations were brought in to cover certificates for alluvial mine managers. Suggestions were made by different people and the regulations provided that the present holder of mine managers' certificates under the Mining Act could not receive this certificate without an experience of 12 months in an alluvial mine worked from the shaft. That is the point to which we take exception. There are many men holding mine managers' certificates who have worked very difficult ground, and who are quite capable of carrying on such work. I think it is wrong to ask men with 20 or 30 years' experience to go and work for 12 months in an alluvial mine before they are entitled to pass an examination which is not a very difficult matter to effect, entitling them to take charge of such a mine.

Mr Kimbell.—Are they qualified men?

Professor Waters.—Yes. They are men with certificates under the Act. I am one myself and I would think it hard if I could not take charge of an alluvial mine until I had put in 12 months' work. There is a possibility of a certain amount of this class of work going on and in order to get managers under the present regulations we would have to get them, say, from Australia, especially Victoria. They would get their certificates by exchange under certain conditions. That would mean that our own men would be deprived from working and these men would get the positions. Any mine requiring such a man would have to import him, whereas I maintain that our own men are quite capable of carrying on this work. If the alluvial industry is to go on managers will be required and I think the regulations should be such that men holding

certificates as mine managers under the Act should be allowed to manage these mines. Otherwise the mines will not be able to get managers, and the work will be stuck up until they get them. Our men have often wider experience in that work than some who are engaged solely in alluvial mining. I move the adoption of this remit as it is printed.

Mr Sligo.—I second the motion. I can see a difficulty attaching to the position. I have worked in both alluvial and quartz mines. The two systems are in a great measure different, but after all the same principles in connection with timbering etc., are adopted. If it is necessary for a man holding a quartz manager's certificate or a lode manager's certificate to put in 12 months' work before managing an alluvial mine I would like to ask what mine he is going to get his experience in. I can understand that the Government is probably taken at a disadvantage in connection with this. Hydraulic mining has reached the last stages of inefficiency. They have followed the deep leads down for 50 or 60 years in the case of the Kildare mine at St. Bathans, and it is impossible to follow them any further. The difficulty is to obtain managers for that class of work. It is necessary that a certificated manager shall be employed, and when these people had to bring one over from Australia when they were ready to start a little difficulty was experienced.

Mr Byron Moore.—It seems to me that if the regulation is enforced it will be the end of deep alluvial mining in New Zealand.

Mr Kimbell.—I do not know of any regulation. I think I can clear the matter up. About six months ago, and arising out of a proposal by a company promoted in Otago to work the deep leads in the vicinity of St. Bathans, the question cropped up as to whether regulations should be made to provide for the examination of alluvial mine managers. A board is constituted under the Act to deal with all matters of that kind. After making inquiries, and in order to get over the difficulty brought about by the fact that a manager had been brought from Australia, the board decided to draft regulations dealing with the matter. These were submitted to me in draft form, and I raised the question whether the secretary had submitted copies of the draft to the board and the inspectors of mines. He said he had not, and I told him to do so and to let me know the results. The replies seemed to indicate to me that the majority of the board were not in favour of the regulations as drafted in toto. The majority took strong exception to the regulation which required the holder of a first-class manager's certificate to pass an examination in two special subjects dealing directly with deep lead mining. I raised the question as to what steps were taken in Victoria to protect the holders of first-class mine managers' certificates when their law was first passed. I wanted to know if they were granted service permits. Up to the present that question has not been answered. In the meantime we decided to cut out that particular regulation until we heard definitely from Victoria so that the regulations did not contain the one to which Professor Waters and others have taken exception. We try to maintain similar efficiency in New Zealand in connection with the passing of examinations as that obtaining in Victoria or New South Wales.

that was the only argument I could see in favour of the proposal. I know that the holder of a first-class mine manager's certificate has in years gone by worked on deep leads. Several years ago a special section prescribing regulations for alluvial mine managers' certificates was passed, but so far nothing has been done, and at present there is nothing to prevent them from acting. If this meeting is against the principle of requiring the holders of first-class certificates to pass in these two or three special subjects, it can pass a resolution to that effect. It will no doubt, be of great help to me later on.

Mr Horn.—If a man who has been working all his life as a miner and sinking shafts, is required to obtain a certificate for alluvial mining it will be impossible to get men. I think the story about the mine manager at St Bathans is not quite cleared up. That man was a practical man, and had been working for many years in Australia. He came over here with a Victorian certificate that was gained by use, but when he arrived in New Zealand he was stuck up. They would not give him a service certificate here because he had gained his certificate by service and not by examination in Victoria. I hold that in exchange of certificates between Victoria and other parts of Australia and New Zealand should take effect. Our young men who have got certificates in New Zealand will be deburred from getting positions on the other side if we adopt that hole and corner business. We have got to the stage that instead of putting obstacles in the way we should give them every facility—(Applause). If half a dozen men took up a run and the law required a certificated manager, where would we get him? It is a new departure and no one has studied for it. In the present state of mining I say it would be a very bad thing.

Mr Moore.—Are we in order in employing a manager with a quartz ticket in charge of an alluvial mine?

Mr Kimbell.—Have you such a man employed?

Mr Moore.—Not yet.

Mr Kimbell.—Well I am not going to answer that question.

Professor Waters.—I ask the meeting to pass this remit and we can consider it with our final report when the matter can be looked into. It will show the mind of the meeting if we pass the remit. There seems to be a little doubt whether we are right or whether the other party is right. I think Mr Kimbell will accept it if we send it on, and it will show the officers of the department that our idea is that the holders of certificates under the Mining Act should be granted alluvial mine managers' certificates without further practical experience.

Mr Kimbell.—Do you contend that our standard should be equal to that of Victoria?

Professor Waters.—Certainly.

Mr Kimbell.—Then if they have to sit for a further examination should we not continue it here?

Professor Waters.—The examination is not a bad thing. It is the 12 months' experience that is the trouble. I have made suggestions so that cases should be considered on their merits by the Board of Examiners.

The President.—I think the remit should go forward in order that our men may get an equal chance with Victorians.

Mr Sligo.—Mr Moore asked a question with reference to the present regulations in regard to mine managers' certificates. The question is whether a man holding a first-class mine manager's certificate could take charge of an alluvial mine without 12 months' further experience.

Mr Kimbell.—The question asked by Mr Moore brings in a very involved legal point. I am not a member of the Board of Examiners, and have nothing to do with it. Its recommendations are sent on to me, and so far as I know the holder of a first-class mine manager's certificate is in no worse position now than he was before the regulations were gazetted. I really cannot answer Mr Moore's question off-hand. In 1914 provision was made that the Government might issue certificates for men in alluvial mines, but when a man was brought from Victoria it was discovered that there were no regulations dealing with the matter. I directed the board's secretary to write to Victoria to find out what was done with the holders of first-class certificate, but we gave had no reply, and the position now is as it was before. In at least two cases men with first-class certificates have managed alluvial mines in New Zealand.

Mr Sligo.—Why should the New Zealand Government write to Victoria with reference to certificated managers there, because the work done there is very different from what is carried on here? Alluvial mining there is very much more difficult and dangerous than quartz mining. We can understand Australia requiring very stringent regulations, which are not required here, where we have not the same difficulties to contend with.

Mr Kimbell.—The general policy throughout Australia is to maintain an even standard of qualification, and that may be the reason that actuated our Government in putting through regulations requiring men to pass an examination.

The remit was adopted unanimously.

Remits B (4b) and B (5b).—"That in giving aids for prospecting the aim should be to concentrate on larger work carried out under expert guidance," and "That in each mining district there should be constituted a Prospecting Board."

Mr M. Paul.—I have had about 40 years' experience, and for the last 18 years I have had control of all the Government grants in the Hauraki district. Yesterday it was suggested that the old prospector was dead. The work of prospectors has been very unsatisfactory, and I am convinced that if you are going to do any good for the industry prospecting must be led by competent men. First of all, the ground should be marked out, and I think a geological survey party could indicate localities which it thought were worth prospecting. If, after

that is done, you send out prospectors under qualified men, and see that the work is done, I think you will soon find a revival in mining.

Mr Macdonald.—The money should be spent on organised parties under competent leadership rather than on single prospectors.

Mr Nicholson.—I think the days of the single prospector are not past.

Mr Sligo.—I would like to say a few words in support of Mr Nicholson's statement. I spent a day looking over Naseby a few weeks ago and there is not the slightest doubt in my mind that there is still a great deal to be done there. It was pointed out to us that people were working good stuff 1000ft up. I have not the slightest doubt that there are deep deposits on the plain but so far as I know the Government has done little or nothing to prove them. In several places the deep leads have been followed down for 100ft or more and that at a time when there were many difficulties to contend against. Between the old Hamilton diggings and the old Hyde diggings, and across the Tueri gold has been got in the deep ground but the miners could not carry on for want of capital. I think there is scope for the Government to prove whether these leads are worth bothering with or not.

Mr G. L. Tacon.—The meeting seems to be of one opinion and the thing is how to give effect to that opinion. Mr Downey has a clear cut scheme. I would suggest that if he has a recommendation to the Government that a board such as that proposed by Mr Downey, should be set up by it.

The President.—I propose to take the matter in two separate motions. The formation of a board is a matter of policy and I think we might first take the discussion on that.

Mr Kimbell.—I cannot let Mr Sligo's remarks pass unchallenged. It is quite evident that he is not familiar with what has been done in Otago in prospecting for gold. We have had a Keystone bore in the vicinity of Teawhenua for the last 15 months.

Mr Sligo.—I said the bore was not available.

Mr Kimbell.—That bore was lying in the vaults for two years. I remember the time when a large sum was granted for putting down a shaft in the vicinity of Naseby. That was granted to a Mining Association. The department has also gone to the expense of sending Dr Henderson down.

The Hon. R. Scott.—It seems to me that this discussion is circling round Central Otago particularly the Naseby district. I have been acquainted with the Naseby district for 40 years and the results of the money expended there have been rather disappointing to me. It is just as well that members of the conference who are not acquainted with the local conditions should know something about them. It is over 40 years since the miners in Naseby were so convinced that a deep lead existed below the Maori bottom that they clubbed together and sank a shaft a very expensive matter in those days. They sank to a depth of approximately 340ft but their money then

ran down. They got some Government assistance, but at the crucial period, when they were at their last extremity, the shaft was abandoned. I induced the Hon. R. McKenzie to send down a Keystone borer, but when it arrived I found to my dismay that its capacity was only 250ft, and it was of no use to us. The testimony of the old miners is that a deep lead exists at Naseby, and I am convinced that a deep lead, or leads, will be worked there some day. The question is how far the Government is going to assist in ascertaining what is down below. I know what the individual prospector did in the early days, and I am afraid you will not get the individual prospector to-day to do anything like what the old miner did 40 years ago. Most of the ground in Otago and Southland except what is covered by bush, has been fully prospected and scratched over. We must now go in for something that will go below the surface and test ground that is proved by geological information. I think we must get up-to-date methods in our prospecting.

Mr Turnbull.—I have been prospecting for about 35 years, and I would suggest that if a prospector makes a discovery more than two miles from any working claim, he should have the right to that discovery for two years, under Government protection, provided he does a certain amount of work.

Mr Macdonald.—The Minister said yesterday that the department was prepared to aid prospecting. The question is how the aid is to be applied. I think it comes to this that all the easily-discoverable gold has been found, and it now remains to prove the deep leads as workable propositions. Any aid which the Government can give should be given in that direction.

Mr Moore.—Unless you have expert supervision the money is thrown away.

Professor Waters.—I would like to explain how these remits were framed. A committee went through the papers, and decided to put down certain questions that arose out of the papers in order to get discussion. The first remit mentioned above was suggested by Mr Downey's very thoughtful paper, and I think we should pass it as a general resolution. We all recognise that the Mines Department has been quite generous in giving money. I say that in all fairness to the department, but many of the inspectors have told me that it would be better to concentrate some of that money on special and larger work under expert guidance. In the discussion on the paper I think the idea was pretty strong that prospecting must be carried out under organised control. We are not saying that the department is not helping the industry. I think it is. The second remit mentioned above is a suggestion arising out of the paper, and out of Mr Downey's scheme, the idea being that in each mining district there should be formed some sort of board, which may meet only once a year. There is a Prospecting Board or a board which deals with large grants, and which meets now and again, but if someone were associated with the inspectors of mines to discuss prospecting and prospecting grants, I think it would help the department. There is another remit asking how best metalliferous mining can be aided. That opens up a very big subject. I think it is by prospecting work that we can aid mining. Prospecting votes

should be concentrated on certain work with advice by members of the Geological Survey Department and any other technical men they wish to call in. I think that after due consideration the committee decided that it would like the remits to go forward in that form as an expression of the opinion of the conference.

Mr J. Horn.—Keystone boring is a different class of mining from prospecting, but the Government machines are not always available.

Mr Kimbell.—There are two machines in Otago to-day—one at Kurow, and the other at the Lowburn.

Mr Horn.—We want two machines, and we must have machines that will go to 1000ft.

The President.—I agree that the deep leads can be effectively prospected only by boring, and I think the deep leads at Naseby are worth testing.

Dr Henderson.—They have no definite deep lead so far as I can find out.

Report B (1) was then adopted.

Mr G. L. Tacon.—The question of oil does not seem to have been taken very much into consideration at the conference, and there is no remit about it. I move, "That in the opinion of this conference a comprehensive and thorough geological survey of all the potential oil measures of the Dominion is of urgent necessity to enable test drilling to be conducted with a prospect of success, and that to render this possible, subject to the existing oil rights actually being exercised, the Government be urged in the national interest to prepare and pass special legislation reserving to the Crown the sole right to grant licenses to prospect for and win petroleum from any land or lease in the Dominion, full compensation to be paid to landowners or occupiers for any damage done, and a fair rate of royalty to the owners for any oil won." That, I take it, is really Mr Kimbell's opinion, and it is endorsed very strongly by Mr Ferrar's very interesting paper. I think the experience of Egypt in oil research is fairly applicable to this country. In Egypt they found nothing for a long time, but since they had a geological survey made they have gone ahead. Unless the oil country in New Zealand can be looked at properly I think any boring done must be more or less in the nature of blind stabbing, and there cannot be the best prospect of success for the money spent. If we go on as we are going we may never get any oil at all, and the owners of the freehold lands will never get any tangible reward. They may get money for option rights, but that is nothing.

The President.—I think we are all agreed as to the need for a survey of the potential oil-bearing areas, but as to the rights of the Crown over freehold land that is a matter for the New Zealand legislature. I think no harm can be done in sending this remit forward.

The motion was carried.

Mr Tacon also moved: "That this conference believes that any oil rights granted should be under strictly British ownership and control, both as to exploration and to work."

The President.—This affirms a principle with which we all agree.

The motion was carried.

Remit B (5) was carried without discussion: "That in each mining district there should be constituted a **Prospecting Board.**"

Remit B (6): "How best can metalliferous mining be aided?"

The President.—That opens up a very important question, and would stand a week's discussion. If anyone has any concrete ideas apart from the suggestions already put forward he would be glad to hear them.

Mr Banks.—I have a few ideas as to how the industry might be helped in connection with the production of gold. I believe there are some profitable finds to be made. I am referring chiefly to reefing in the North Island. So far as I know the assistance towards prospecting has resolved itself mostly into helping one or two men to prosecute a little work in which they are interested, and nothing on a big scale has been done for many years. My view is that the most promising areas should first of all be indicated by the Geological Survey Department. Otherwise a great deal of time might be wasted in running over country where there is no possible hope. A company should be formed with scientific trained men at the head of it, because it is not only gold that has to be looked for. Other minerals than gold should be known. If possible a really good working prospector should be with the party, and the hush-craft necessary to explore the country should be possessed. I think that if a bonus were offered by the Government to any company finding a new district or for gold produced in a new district, a stimulus might result and renewed activity be produced. I think there is more scope in the South Island than in the North Island. There is some very rough country in the South Island that is not properly explored yet.

Mr Nicholson.—As far as I can remember about 130,000oz of gold were produced last year, and if a bonus of 5s per oz. were paid that would be an expenditure of about £30,000 over all the mining companies in the Dominion. What the Waihi Company does not require to-day it might require in a year or two. There is a bonus in nearly every other industry, and this industry has been badly treated in regard to the price of gold before. I think we are not asking too much in asking for a small subsidy.

Mr W. H. Paterson.—One matter which affects the gold industry very largely is the question of duty on machinery imported in connection with gold mining. The Shotover Gold Mining Company is at present erecting a new suction dredge on the Shotover River. When we started these operations it was understood that mining machinery came into the country free of duty but when our machinery arrived at Bluff we were told that it was subject to a duty of 10 per cent. We protested. When the second lot of machinery arrived the Customs officials discovered that they could get a duty of 26 or 27 per cent., and the result is that we are paying under protest. The

whole of the machinery runs us into the payment of duty of 17 or 18 per cent, and the total amount of duty is between £2500 and £3000

Mr Kimbell.—On two occasions during the last three or four years we have taken up cases with the same department, and if you give me full particulars I shall be very pleased to take this matter up. Otago is the pioneer in regard to dredges for winning gold, and I cannot understand why you did not get your dredge made in New Zealand.

Mr Paterson.—I do not know of any New Zealand firm that manufactures drills. I understand that the Government imports its drills.

Mr Kimbell.—No, we make them ourselves now.

The President.—I think all mining machinery should come into the country duty free. Instead of interpreting the regulations sympathetically the Customs Department always interprets them against mining. Mr Paterson suggests that a mining expert should be attached to the Customs Department or be referred to in connection with the importation of mining machinery. There is precedent for that. In the time of the Atkinson Government a great amount of duty came into the country. The Customs Department appointed a man to value all the invoices, with a view to assessing the value and deciding the amount of duty. The Mining Department is always willing to put up a fight for the protection of the mining industry.

Mr Moore.—In the Customs tariff there is a provision that machinery peculiar to gold mining is free of duty, but that is a mere word and a delusion and does not help us at all.

The President. That is where the expert would come in. He would decide whether the machinery was for mining or not.

Mr Smythe.—I think this matter should be taken up by the Government.

Mr Sligo.—We have hand boring plants made here but the Government has facilities for manufacturing plants that private individuals or companies have not. I do not know whether Mr Kimbell wished to infer that the Government made machine boring plants. I have a good deal of sympathy with Mr Paterson.

Mr Horn.—Mr Paterson states that the Customs Department informed them that the machinery would come in free. I suppose they explained the nature of the machinery and that the Customs officials knew all about it but now there is a duty of close on £1000. I think that when this is put before the Government some suggestions should be made through the Mines Department that a company placed in the same position should have a special rebate in some way.

The President.—I move that the suggestions that have come of the discussion be sent forward.

Mr Sligo.—We are asked to suggest something to aid metal-liferous mining in Otago. Although we have geological reports in connection with Central Otago we have no geological survey of our deep leads. The Government might see its way to give some assistance to deal with these.

The President.—I shall put that among the suggestions.

Mr Auld.—I suggest that a little more attention be paid to deep sinking in our quartz mines. Our mines are shallow in comparison with other mines, and so people say we are getting down to the limit of our quartz.

The President.—It is not very clear how this can be done, but the suggestion can go forward.

Mr R. T. Stewart.—We all realise how much New Zealand owes to the mining industry. The attitude of the Customs Department in connection with the importation of machinery for mining purposes means that that department has its hand on the throat of the mining industry and I think the Mines Department should protect the industry.

Mr Sligo seconded Professor Park's motion, which was carried unanimously.

Mr McIntyre.—I agree to the amendment with pleasure.

The motion was withdrawn and Mr Brown's proposal was carried unanimously.

Mr J. C. Bayne moved the following remit: "That this conference should consider any further means of increasing the safety in, and reducing the accident rate in connection with our coal mines.

In placing the remit before the conference, Mr Bayne said that though our accident rate was lower than in the British Isles, it was higher than in some of the Continental countries. Although there might be some excuse for the high rate, there should certainly be some means by which it could be reduced. Of late, he was sorry to say, there appeared to be a tendency towards an increase in the accident rate of the

Dominion For instance, the number of accidents due to the handling of explosives was higher than it should have been, whilst eye accidents appeared to be more prevalent of late than had previously been the case. Accidents due to falls of ground were not likely to be reduced.

Mr E. S. Wight stated that he had given rather consideration to the best means of abolishing eye accidents. He had obtained gauze shields and had supplied every miner with one and obtained his receipt for it. On one occasion he had gone into the mine and found a man without his shield and had ordered him to wear it. The man refused and was ordered out of the mine for disobedience of orders. The union took the matter up, and he (the speaker) was instructed to re-militate the man and was told that he had no authority to force a miner to use an eye shield. He had known of many eyes which had been lost and need not have been had eye shields been used. If he had the power he would force every miner to use an eye shield. He could not see where the remedy lay. If they used precautions in one instance and neglect in others they were responsible. The men seemed to delight in claiming damages from the companies and he thought that accident and relief funds and amounts allowed by lodges had a great deal to do with the many accidents which were brought before their notice. He had known of men claiming for damages received in accidents which to his mind had never happened in the mine at all. He suggested that a law might be framed compelling the men to wear shields.

Mr W. Carson said that gauze shields were necessary for the prevention of eye accidents, and agreed that at times the men delayed having their injuries treated. The only thing to do with an accident to the eye was to go to the surgery and have it treated immediately. He thought that pressure should be brought to bear with a view to having it made compulsory for the men to wear eye-shields. Kantangata coal was apt to fly, and he had found that the use of a gauze shield went a long way towards preventing accidents.

Mr George Duggan thought that the shield was taken more advantage of than it had been. He had advocated its use for many years, but he had seen shields which were not suitable. He thought that if a good shield were devised and mine managers empowered to make the miners use them, the problem would be more than half solved. In reference to safety-first propaganda, he was in favour of it, but he thought that it should not be spasmodic, but carried on always. **Mr Penseler** had suggested a safety engineer. The idea was a good one, but unless he were given statutory powers to act, no notice would be taken of him, and he would be powerless to do anything. The main point was that an ambulance should go hand in hand with any safety-first propaganda, and that there should be thoroughly trained ambulance corps established at every mine.

Mr Carson said that although the gauze shields had proved fairly effective in preventing eye accidents, he had known of cases where coal had gone right through the shield, and that frequently miners, when they were issued with gauzes, were loth to use them. What was required was statutory power to compel their use. Better lighting could also be considered with a view to reducing eye accidents.

Mr Strongman said that he had seen numerous gauze shields, but they were not always successful. He knew of one case where a miner had devised his own shield, which was successful. If a shield could be perfected that would not injure the eye, well and good, but in numerous cases shields were given to the men which were injurious to the eyes. The miner argued in this case that if he went blind without the shield, the management paid, and if he went blind by using it, he paid. In the case of cuts, they often became septic through the men's neglect to take proper care of them, and although bandages were provided handy in every mine, he had frequently seen them used for sanitary purposes. Iodine should be put in a convenient form and issued to every man. The big question was the deaths of miners through falls of earth, and there was potential danger when pillars began to fret and props started to crush. To reduce this danger he would advise better methods of working. If the size of the average mine pillar were compared with that specified by text books it would often be found to be 50 per cent smaller than what was laid down by the text book. It was no wonder that falls were prevalent. Thus, in most cases, the cure would appear to be an increase in the size of pillars. In reference to explosive accidents, faulty powder was often responsible. He had known of a deputy who fired a shot—a good shot—which sounded as if it had not done its work. The deputy went back to look again, and the shot went off the second time and a piece of flying coal hit a miner in the eye. On investigation, it was found that the explosive

had deteriorated. Another source of many accidents in mines were runaway trucks. Many mine trucks were fastened with single couplings only, and he maintained that double couplings were necessary.

Mr W. M. Barclay agreed that the seriousness of many eye accidents was due in many cases to inattention, on the part of the men who received them.

Mr Bayne, in reply to the discussion said that he was pleased at the discussion which his remit had brought up. He agreed with Mr Bishop that most accidents were due to ignorance, and that safety-first propaganda should be carried on, but though the idea had been put before the Mines Department he did not know how far it had gone in the matter. In reference to Mr Penseler's suggestion regarding a safety engineer, something of the kind was in vogue in the British Isles. In the matter of eye accidents, and their prevention by the use of gauze shields, he was not satisfied that the shields now in use were all that could be desired. He thought it inadvisable to urge legislation that the men could be compelled to wear eye shields, and in his opinion better results could be obtained by educating them. Besides there was a danger of legislation of this kind being overdone. Mr Duggan's suggestion in reference to night-work classes was good, and as he had said, a large percentage of serious eye accidents were due to inattention. Ambulance classes would tend towards having better care taken of eye wounds. As chairman of this discussion he had given him a great deal to think of.

The Hon. W. H. McIntyre said that he did not see that the discussion would get them anywhere. The safety-first propaganda was necessary, and in his opinion a resolution should be passed to the effect that the time had arrived for a safety-first crusade to be initiated in the country, and the resolution forwarded to the Government.

Mr W. A. Flavell said that he considered a safety-first campaign very desirable, but he did not know how far the Government would go in the matter, it lay largely with themselves. He was appalled by the many mine accidents which occurred yearly throughout the Dominion, and he would be glad of any opportunities of discussing a means of their prevention. He was not under the impression that they should get more in touch with the men and educate them. He could not see that they could go much farther. As far as his own company was concerned he would be pleased to receive suggestions from the men, not so much for the company's sake as for the sake of the men themselves. He very much doubted whether they would get any further by new legislation, but if the question of guarding against accidents were brought before the men, there was no doubt that this would go a long way to putting matters on a better basis. The whole question seemed to be whether the meeting should consider it advisable to send to the Government asking for special legislation in this matter. He was of the opinion that a great deal could be done by making available (in the case of eye accidents) eye-shields, and urging the men to use them in their own interests.

Mr McIntyre said that legislation could never take the place of education. He would suggest that the conference consider whether or not a safety-first crusade be launched through New Zealand, and a copy of the propaganda be sent on to the Government.

Remit C (1). "Re working of mines: Can any steps be taken to improve the methods so as to increase the quantity of coal won and reduce the amount of small coal?"

Mr Flavel (Chairman).—I think everyone interested in mining must realise that this is one of the most important remits on the paper. This is a perennial subject, and is a really live matter with those who have to handle coal. We think the very best methods are not being adopted. We know that some collieries are producing a large quantity of small coal, which is unsaleable. I sometimes feel that if greater care were given by the managers and their deputies to the amount of explosives used in each shot and viewed each place carefully until the men were trained in the use of explosives, it would probably have a good effect in the matter of small coal. In some mines the coal is very friable. When there is so much competition from electricity coal is becoming very difficult to dispose of on account of the small size. Surely some mine manager could make suggestions in the way of showing how coal can be got in a better way than at present. Coal-cutting machines may solve the problem to some extent. Is there any manager here who has had experience of coal-cutting machines, and who can say whether machines would save the breaking of the coal before a shot was put in? Surely there is a great deal of valuable information in the possession of men at this conference that can be printed in the report. I am sure Mr Armstrong was about to tell us that he thought a saving could be made in the matter of slack coal if machines were used.

Mr Bayne.—A good deal of ground has been gone over in the discussion on the paper relating to mine fires. It appears to me that in several countries where the seams are about the same thickness as those in New Zealand they are able to extract over 80 per cent. of the coal. In New Zealand we do not extract more than 40 per cent. before the mines are abandoned. The difference, in my mind, is due largely to the pillars in the first working being left far too small. That is the principal cause. Secondly, our coals are liable to spontaneous combustion, and the introduction of the panel system in many mines would save large areas from being abandoned and lost. These two steps are most certain to give good results. Coal-cutting would give a much smaller percentage of small coal. Many seams dip at a high angle, and that makes it very difficult to work some classes of mines. The roof is not as good as in New South Wales, and therefore the application of machines is limited. In many mines I think they could be adopted with good results. There is one direction in which the percentage of slack coal could be reduced, and that is in shot-firing. Not long ago I examined the method of shot firing, and I can say it was bad, and calculated to give a large percentage of screen coal. If the managers attended to that part I think they would get something that would justify their efforts. In America they have changed their methods, and they have found that the change increased the quantity of round coal by about 7 per cent.

Mr Brown.—Small coal is very difficult to get rid of. The question of machinery has not been overlooked in the mines in New Zealand. The Westport Coal Company has electric machines. We have had a varied experience of coal-cutting machines in mines. Under certain conditions they have a decided advantage over a hewer. An expert from America was taken round the mines with a view to ascertaining whether we could use the class of machines they used there but the reports were unfavourable. The only machine that would give good results was a percussive machine and I think it could be used in some parts of the mine with satisfactory results. Miners are averse to machines underground and there is difficulty in getting them to give you the results desired. We have to face that in the near future if we are to get the best results. The difficulty has been that a machine does away with a certain number of men and the men object to it. Shot firing should be very carefully scrutinised. In many mines it is probably very carefully watched. So far as a maximum output of coal is concerned I feel that a modified pillar system could be used with advantage. I feel sure that we shall try coal-cutting machines in some parts of the runs, but a heavy machine will not do in heavy grades and you must have a percentage of colliers working on ordinary tonnage rate. The whole question is one of great importance and we should consider every possible means of increasing the size and production of coal.

Mr Armstrong.—I can endorse Mr Brown's comments with reference to the pillar system for some coal and coal rates for increasing the quantity. I believe that in many mines excavators could be employed quite successfully and increase the output by at least 10 per cent. Mr Brown is right in saying that the men are averse to coal-cutting and there would be great difficulty in getting them introduced. Some men could not handle the machines. Machine-mining collierisation, and the machine could be used in one way of cutting. On the Martland field they are taking an 80 per cent and 80 per cent of it is machine cut.

Mr Leitch.—There is no doubt about the size of the pillars being a big factor in the amount of small coal produced. When the pillar is too solid and you have to use explosives the amount of steam coal will be greater and therefore every manager should prevent excessive weight on these pillars. Another big factor in slack coal is excessive shot firing. The striking feature about explosives is the increasing number of shot. The miner has discovered that the permitted explosive will do what the ordinary black powder will not do—that is blast in the solid. The handling of the problem is a great deal in the hands of the shot firer. If he does his work properly I think you will not hear so much about the damage which high explosives are doing.

Mr Wight.—With permitted explosives you put in a dummy cartridge and do not ram it all. You ram the last two inches tight with clay. We put three plugs in, and get a good shot. We have been carrying that on for, I suppose 15 or 18 months, and the men are quite satisfied. They are using less explosive, and we consider we are getting about 2 per cent. more round coal. You can try it for yourselves but we are continuing.

Mr Armstrong.—We adopt that method at our colliery, and there is no doubt that there is an advantage in having an air cushion when the shot is properly prepared, but the trouble is that it is not properly prepared, and we do not get the quantity of round coal we should get.

Mr Langford.—I might give an experience with coal-cutting machines. I had all the coal carefully screened, and the result was that the quantity of slack was reduced from 30 per cent to 14 per cent. That represents a saving of 16,000 tons in an output of 100,000 tons. In our 40ft seam I believe we are getting 90 per cent of the coal. I think there is only 2ft or 3ft between the top and the bottom rib.

Professor Park now took the chair.

Re mit C (2). Re utilisation of slack coal: that the department be asked to continue in its experiments and efforts to determine the ways in which coal slack can be utilised.

The President (Professor Park). I think this remit may very well be passed without much discussion. The mines department should continue its research for the sake of the coal-mining industry.

Mr Duggan.—I would like to add. That the coal owners should also be asked to assist in the experiments, particularly in the way of the utilisation of pulverised coal and briquetting. This morning we heard a lot about briquetting, but we have not been informed of the methods of experimenting in regard to pulverised fuel.

Mr Kimbell.—The Minister expected to get some practical views from practical men as to what further steps could be taken, but so far I have not heard any practical suggestions.

Mr W. A. Flavel.—This morning we had a very interesting paper by Mr Pensker on the briquetting of coals. In the discussion there were some comments in the direction of indicating that the Government should make experiments in regard to the use of pulverised coal, and I think the thing has been pretty well threshed out. It has already been talked over, and I think the general impression was that the Government was to be thanked for the work undertaken, and that the work done at the Government laboratory was very useful. The speakers thought it might be extended along the lines of using pulverised coal. Mr Bishop and others spoke along those lines.

Mr McIntyre.—I think this question justifies the establishment of a Research Board in the Dominion. It wants the undivided attention of a staff of scientists. It is a question of costs and ways and means, and I think the coal owners would be prepared to pay a small royalty, say $\frac{1}{2}$ d per ton subsidised by $\frac{1}{2}$ d from the Government. There would be sufficient revenue to employ men who would be worthy of this research. If we pass that pious resolution we shall not solve the slack coal problem. I would like to get an opinion as to the establishment of a Research Board. They have set up boards in other parts of the Empire. The British Government not only does considerable research work, but contributes $\frac{1}{2}$ d per ton towards a fund. I think a Research Board should

be established, and this is the gathering from which such a suggestion should come. If such a suggestion were put before the Minister it would give him a lead and no doubt assist in obtaining the necessary finance. One halfpenny per ton subsidised by the Government would bring in about £8000 or £9000 per annum, and would not be a great drag on the industry. It would be of great benefit to the coal owners and the community.

The President.—I think Mr McIntyre has given us a valuable constructive suggestion. I am strongly in favour of a board, and on the board there should be representatives of the Mines Department, the Railway Department, and the Public Works Department.

Mr Flavell.—As a representative of the coal owners and a member of the Coal Owners' Association I would suggest as the coal owners frequently meet, that a resolution somewhat in this form be passed: That the Coal Owners' Association be asked to consider the advisability of recommending the Government to set up a Research Board to investigate the best methods of utilising small coal at the collieries and the best means of providing the revenue necessary to maintain such board. In my opinion the coal owners should not be backward in finding out how the small coal should be utilised. It was pointed out this morning that the Government gets a royalty on every ton that comes out of a mine, but as the small coal is unsaleable the whole of the revenue from it is lost. It would be to the Government's advantage to find out how that coal can be utilised. I agree that the coal owners are going to derive some benefit and I think they will not be backward in contributing what is necessary towards research work. If they have not advocated a Research Board earlier it is because there is a Research Board in the Old Country and its work is available to us. Probably research here might be a little more varied in finding out how we can utilise small coal, but the research done at home is valuable to us, and that is always available through the various colliery papers. I move the I point made by me at the beginning of my speech.

The motion which was seconded by Mr McIntyre was carried.

Mr G. R. Chaceman.—If a Research Board is set up and a tax is put upon us I take it that tax will be for only a limited period.

Mr Flavell.—That will be a matter for investigation.

Mr McIntyre.—I think it should be for five years.

At the request of the Chairman, Mr J. F. McEadden spoke to remit C (3). That the present method of carrying out oral examination for mine managers is extremely expensive to candidates, and steps should be taken to simplify and lower the cost of the method."

Mr A. F. O'Donnell seconded the remit, which was adopted without discussion.

Remit C (4). That the charge made for gas testing certificate (1s 6d) is too high, in view of the expense that many candidates are put to in order to proceed to testing stations."

Mr McIntyre moved that the charge be 2s 6d.—Agreed.

REMITTS DISCUSSED BY FULL CONFERENCE

PROFESSOR PARK IN CHAIR

Remit A (1) "Is the trend in mining legislation during recent years too much by regulation and not sufficiently by amendment of the Acts?"

Mr J. R. Smyth stated that this would appear to be disposed of by the promise given by the Minister that the Bill was to be disposed of at the next sitting of Parliament.

Hon. Mr McIntyre said that the question of consolidation would have to be taken into consideration. What really was required was that it should be laid down what should be governed by legislation and what by regulation.

Mr J. C. Bayne said that there was one difference in doing things by legislation and that was that where matters sometimes went through the House without difficulty, once they were through they could not be altered without a good deal of trouble. On the other hand a regulation was easy to alter.

Mr E. S. Wight agreed with Mr Bayne and considered that as long as the present system obtained matters were very distinctly.

Professor Park asked if Mr Mance (Under Secretary of Mines for New South Wales) could enlighten them as to the method of procedure in New South Wales.

Mr Mance said that the question was just a turning in New South Wales as it was in New Zealand. Their Act contained no regulations, and many rules which were one of date could not be amended without going before the House. The Bill should contain all the principles, which would then be defined in the Act.

Mr McIntyre pointed out that the regulations under the Mining Act did not come into force until approved of by Parliament. He considered that the conference was compelled to answer in the negative and that it would be advisable to adopt the system in Great Britain and New South Wales.

Mr P. G. Morgan agreed with Mr McIntyre and stated that the remit should be answered in the negative.

Mr McIntyre then moved the amendment. That this remit be answered in the negative, and that this conference recommend the Government to adopt the method in vogue in Great Britain, and that in New South Wales. He then moved that seconded by Mr G. Townsend was carried.

Remit A (2) "That the annual mines statement should be increased in size so that fuller details of mining operations in the Dominion may be recorded and provision made for the insertion of technical papers bearing on recent developments in mining and metallurgy, more especially those likely to be of value to the mining industry."

Mr P. G. Tait (Melbourne) questioned the wisdom of increasing the size of the statement. Nothing would be gained by incorporating articles which could be published in technical journals. The remit was adopted.

Remit A (3). "That the reports of the geological survey should be printed as soon as they are prepared," was carried without discussion.

Remit A (4) 'Re Mining Company Prospectuses —Should the same be submitted to the Minister, or other authority, before issue? Should the Minister have the right to excise any statement made therein? Should legislation be passed requiring the publication in every prospectus, whether for public or private circulation, of a report by a qualified mining engineer or geologist, not financially interested in the venture?"

Mr Sligo strongly opposed the remit. He considered that to require the Minister to excise matter from prospectuses was a dangerous attitude to adopt.

Mr Townsend also opposed the remit on the grounds that the use of the Companies Act were sufficient to enable procedure to be taken against directors who published false statements. Further he could not understand why this remit should apply solely to mining companies. It was not clear to him why authority should not be created to examine the prospectuses of any company as it was just as easy for bogus prospectuses to be issued in connection with numerous other companies besides mining.

Mr McIntyre said that the course outlined in the remit did not appeal to him and he did not think it advisable. It would be useless to submit all mining prospectuses to the Minister unless he were allowed a staff large enough to go through them all.

Mr J. R. Smythe pointed out that our prospect only received consideration. He had seen in the press that the Minister had taken it on himself to disclaim the assertion made by a certain old mining company that it was under the wing of the Government. He considered it advisable that the Minister should have power to excise from prospectuses any statement which would in any way convey the impression that the scheme was backed by the Government.

Mr Wight endorsed Mr Townsend's remarks and said that he could not see why the remit should be made applicable to mining prospectuses only. Such a law should be common to all companies.

Mr Flavell said that he doubted whether the Government would take on the responsibility laid on it by the remit.

The President (Professor Park) remarked that the feeling of the meeting appeared to be against the remit, whereupon Mr Cheeseman moved that the remit be rejected, the motion being carried.

Remit A (5) "That the Geological Survey now concentrate part of its energies on close detail work on mining fields or known mineral deposits besides carrying out prospecting work where deemed necessary."

Mr Bayne said that he would like to hear **Mr Morgan** speak to the remit.

Mr Morgan said that the matter contained in the first part of the remit was being attended to—the department was doing what was required of it—and he could not understand why the remit had been brought forward.

Mr Sligo asked if **Mr Morgan** could tell him where any geologists were working in Otago—if a geological survey were being made, he thought that the fact should be widely advertised.

Mr Morgan said that at present it was well known among coal owners that **Mr Ongley** was, and had been, for some time past, engaged in making a survey of Green Island, Kaitangata, and Milton districts. The Geological Survey Department did not advertise.

The remit was adopted.

Remit A (6) "That the Geological Survey should institute close inspection and recording of all work done relating to the geology of mines and should keep a record of the economic values obtained during mining and prospecting operations."

Mr T. A. Turnbull said that the want of money was hampering this department if more money were granted it better results could be obtained.

Mr Bayne said that for the past three years the Mines Department had been endeavouring to keep permanent records of the geological survey of all coal mines. A great deal of work had been done, and the records collected would be of great value in that particulars of abandoned mines would always be available, which would be beneficial to those wishing to open up new mines in the vicinity.

Mr Morgan moved, and **Mr Flavell** seconded, that as this remit applied most closely to coal mining, the words "geological survey" should be deleted, and the words "Mines Department" be inserted. A motion that the amendment be sent forward was carried.

Remits A (7) and A (8): "That the work of the District Schools of Mines should be co-ordinated with that of the Otago School of Mines," and "That the present system of conducting the School of Mines scholarship examinations should be investigated with a view to rendering the scholarship more attainable.

Professor Waters moved: "That the department be requested to call a conference of the different representatives of the Schools of Mines with a view to co-ordination." This might get over the difficulty mentioned by **Mr McPadden**

Mr T. W. Rhodes, M.P., suggested that a less cumbersome way would be for the directors of the Schools of Mines to submit their syllabus for revision to the head of the Otago School of Mines. An alternative, that the Otago School of Mines draw up a syllabus and submit it to the district Schools of Mines was also suggested.

Mr Penseir said that some years ago he had taken a scholarship in a district school, which was really only an entrance examination to the Otago School. The standard of the latter institution was far ahead of that of the district school in which he obtained his scholarship.

The President pointed out that in drawing up a uniform syllabus the fact that different schools had different specialties was a point that would have to be considered.

Mr Flavell said that a special conference might be able to do it.

Mr Morgan drew attention to the great variation in standards. At Waihi for instance, the standard in gold-assaying and metallurgy was quite equal to that of the Otago School of Mines. His motion was agreed to.

CONCLUSION

Mr F. S. Mance (Under-Secretary of Mines Department, New South Wales), said that he felt that he would be wanting in his duty if he did not tender in more thanks for and more appreciation of the invitation to attend the conference. When the invitation reached him and he placed it before his department, they had immediately on seeing the names of Professors Park and Waters known that it was to be a conference out of the ordinary and advised him to accept. New South Wales problems and New Zealand problems were the same and he appreciated their getting together and discussing these problems. There had been talk of mining declining but he could assure them that this was not the case in New South Wales where, as far as finance was concerned, the position was sounder than ever. He considered that as the population increased so would mining increase. He thanked the delegates for the reception they had given him and trusted that it would not be long before another conference was held.

Mr T. W. Rhodes, M.P., in moving a hearty vote of thanks to the president (Professor Park) and the secretary (Professor Waters) said that he trusted that steps would be taken to ensure the holding of another conference and that 36 years would not elapse between this and the next. The conference owed much to the energy of Professor Waters, its secretary, without whom the conference would probably have not come into being. The motion was carried by acclamation, those present joining in the singing of "For They are Jolly Good Fellows."

In discussing the holding of the next conference, **Mr J. R. Smythe** moved a resolution for the purpose of promoting the well-being of metalliferous mining, there be constituted by this conference a special standing committee, who will continue in office until the next meeting of the conference. In bringing forward this motion Mr Smythe said that his main purpose in doing so was to ensure the holding of further conferences. He thought it would be extremely regrettable if after three days together the conference were to be dissolved. And he like Mr Rhodes did not wish to see as many years pass before the next one as had passed between this and the previous one.

Regarding the proposed committee, and with a view to suggesting names, he thought it would be desirable that those metaliferous representatives whose names appeared on the executive and vice-presidents list would be the most suitable. The names that had occurred to him were those of Messrs Banks, Horn, Rhodes, Scott, Spencer, along with the names of Messrs Beal, Ludon, McGregor, Sligo, and Stewart. Of course, he regarded it as *non propter* that Professors Park and Waters would resume their respective offices as president and secretary.

Mr. Rhodes suggested forming a quorum, but said that if Mr. Smith's motion would ensure the holding of another conference, he would second it.

The motion was carried accordingly.

DANIEL BLACK WATERS, *ætat* 55

After a long illness, Professor Waters, hon. secretary of the Mining Conference, passed over the Great Divide on April 1. He was educated at the Otago Boys' High School and Otago University. In 1881 he gained the Associateship in Mining and Metallurgy, and in 1882 the Mining Surveyor, and in 1900 he was appointed lecturer in Metallurgy at the Otago School of Mines. In 1909 he was raised to the status of Professor. Professor Waters did not publish any research work, but devoted most of his time to teaching. His devotion to his work is a fact which is reflected in the great success of his students at the University examinations. He was endowed with a methodical and far-seeing mind, and in his preparation for the conference made provision for possible difficulties. It was this quality of mind that made him the ideal secretary; he proved himself to be in connection with the conducting of the routine affairs of the Mining Conference. Professor Waters was a member of the Institution of Mining and Metallurgy, London, and of the Australasian Institute of Mining Engineers. As a man, though modest and retiring, he was held in high esteem by all his colleagues, students, and friends. He was twice married, but there was no issue by either marriage.

